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Woods Hole Oceanographic Institution

Use of the High Resolution Profiler (HRP) in the Salt Finger Tracer Release Experiment (SFTRE)

by

Ellyn T. Montgomery

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July 2002

Technical Report

Funding provided by the National Science Foundation under Grant No. OCE-0081502.

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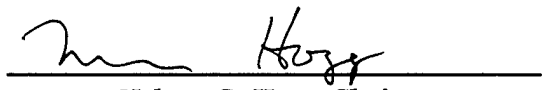

Nelson G. Hogg, Chair

Department of Physical Oceanography

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Abstract

The **S**alt **F**inger **T**racer **R**elease **E**xperiment (**SFTRE**) was conducted in the tropical North Atlantic in 2001. The experimental area was east of Barbados and is characterized by thermohaline staircase features prevalent in the depth range of 200–600 meters. The goal of this experiment was to quantify the distribution and intensity of vertical mixing in a region of thermohaline staircases. Two cruises were required to accomplish this goal: one to survey with the High Resolution Profiler (HRP) and inject sulfur hexafluoride (SF6) tracer, and another ten months later to map the spatial distribution of tracer and obtain additional estimates of diffusive and turbulent mixing rates using the HRP.

The first cruise of the **SFTRE** experiment took place between January 15 and February 12, 2001 on the R/V *Oceanus*, leg 365-2 (**OC365**). An XBT survey identified an area of robust staircases that became the injection site. Then 175 kg of SF6 tracer was injected in nine streaks in a layer with temperature of about 10°C. When the injection mechanism was being replenished, HRP profiles were made in the area of the tracer patch. The profiles yielded estimates of the mixing rates at the start of the experiment. Near the end of the cruise, water samples from the patch were used to map the actual tracer distribution immediately after deployment.

The second cruise occurred between October 29 and December 4 on the R/V *Seward Johnson*, leg 01–12 (**SJ0112**). Its objective was to sample and map the vertical and horizontal distribution of tracer after ten months. The work completed included 172 CTD casts with chemical analysis performed on the water samples, and 165 HRP profiles. Despite covering an area of 500,000 nautical miles^2, only 50–60% of the tracer was found, suggesting higher than expected lateral mixing.

The **SFTRE** included the deployment of a Moored Profiler. The profiles acquired by the MP provide background on the temporal variation of the temperature, salinity, and velocity fields where it was deployed. To share costs of personnel, the MP was deployed and recovered on cruises that followed ours, in conjunction with other mooring activities. The MP was deployed in February 2001 from R/V *Oceanus* and recovered by the R/V *Knorr* in April 2002.

The program was a success, despite not fully delimiting the tracer distribution, because the observations allow more complete quantification of the mixing processes occurring in this region. The inferred mixing intensity was stronger and the influence of the thermohaline staircases more widespread than initially expected.

Overview

The goal of the **S**alt **F**inger **T**racer **R**elease **E**xperiment (**SFTRE**) was to quantify the extent and intensity of vertical mixing in a region of thermohaline staircases. The "salt finger" instability was first reported by Stern (1960). The paper describes a process whereby an initial stratification with warm-salty water overlying colder-fresher water breaks down into small (2–3 cm), closely packed, up and down flowing convection cells (fingers) that exchange heat laterally but diffuse little salt. The result is a vertical advective transport of salt, and to a lesser extent, heat by the fingers. Salt fingering, if sufficiently strong can cause convective homogenization of layers several tens of meters thick separated by thin interfaces with intense vertical gradients, creating a thermohaline stair-case. There is some controversy about the significance of salt fingers in ocean mixing. The combined tracer and microstructure approach of this experiment is expected to clarify the role of salt fingers in ocean mixing, and thus, its contribution to water mass conversion and the general circulation.

Thermohaline staircases have been observed in tropical and subtropical regions where evaporation exceeds precipitation, and heating exceeds cooling. They have temperature and salinity profiles that look like steps instead of smoothly varying in depth. The contrast between profiles with staircases and those with smooth gradients is evident (Figure 1). Typically, within a staircase several 10–40-meter layers of well-mixed water are separated by thin (2–5-meter) sheets in which the gradients are steep. The structure of the staircases is taken as a finescale manifestation that salt fingering is occurring on the high-gradient sheets.

The research program involved two cruises in the tropical North Atlantic, which were completed in 2001. The cruise objectives were:

- select a site for the tracer injection using XBTs
- inject a patch of sulfur hexafluoride (SF6) tracer
- survey the injection area using the High Resolution Profiler (HRP)
- map the spatial distribution of tracer nine months after injection
- obtain estimates of diffusive and turbulent mixing rates using the HRP

A short description of each cruise is presented in this section; with a complete cruise narrative for each presented later in the report.

The first cruise of the **SFTRE** experiment took place between January 15 and February 12, 2001 on the R/V *Oceanus*, leg 365-2 (OC365). After leaving Barbados, XBTs were used to map the extent and intensity of the staircases, which guided selection of a suitable location with robust staircases to inject the tracer. The potential density surface of 27.05 kg/m^3 was selected for the target surface. This level corresponded to potential temperature of 9.930°C, which was typically at a pressure of about 380 db. A total of 175 kg of sulfur hexafluoride (SF6) tracer was injected in nine streaks over nine successive nights. During those days, HRP profiles were completed to quantify the mixing rates during the injection. All the HRP profiles made on this cruise were to 2000 meters, in much deeper water, so the HRP altimeter was not used. Once the injections were completed, five days of intensive HRP profiling further documented the characteristics of the patch of water containing the tracer while the injection equipment was stored and the sampling apparatus installed. Then, water samples from the integrating sampling sled were collected and used to verify the initial distribution of the tracer patch. After surveying with the sled system, several CTD casts to 1000 meters were interspersed with HRP profiles. The water samples collected on the CTD rosette showed the actual tracer maximum at the density of 27.047 kg/m^3, very close to the target. The last activity of the cruise was a meridional section along 55°W, through the center of the tracer patch. The southernmost station was at 10.5°N and the northernmost was at

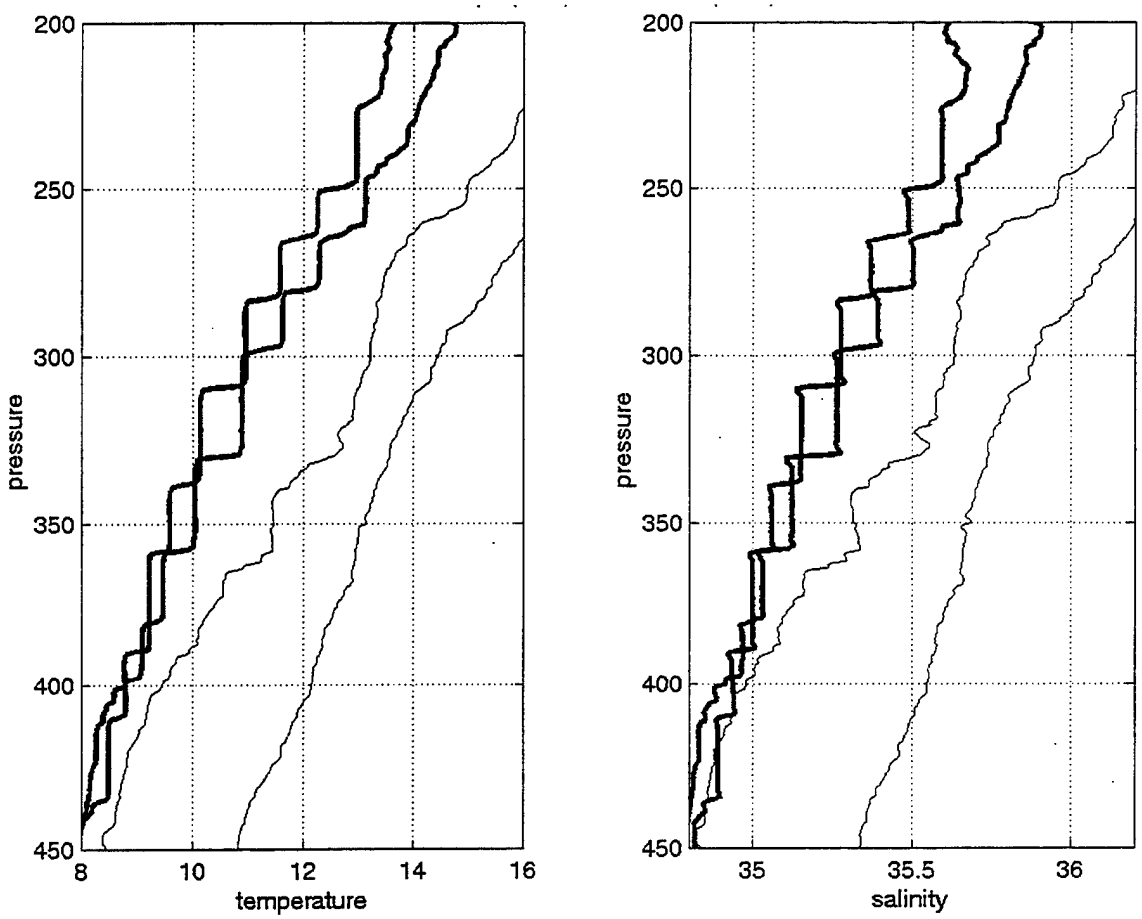

Figure 1: Representative temperature (left) and salinity (right) profiles from SFTRE-2. Thick lines emphasize profiles with steps, and thin lines depict smooth profiles.

15.25°N. By cruise end, 49 XBTs were used and 109 HRP profiles had been completed (Figure 2); the details are provided in appendix A.

The second cruise occurred between October 29 and December 4 on the R/V *Seward Johnson*, leg 01–12 (SJ0112). Its objective was to map the vertical and horizontal extent of the tracer patch, while making additional measurements with the HRP to quantify the mixing rates. Due to immigration issues, the Venezuelan observers were unable to meet the ship by the departure date, so a weeklong survey was undertaken south and east of Barbados. The ship returned to port on November 5 to exchange observers, refuel, and then continue the cruise. The routine operation during this cruise was CTD casts with simultaneous HRP profiles. Water samples were collected on each cast and analyzed during the transit between stations. The CTD casts and HRP profiles were started simultaneously, but the CTDs only went to 1000 meters while the HRPs went to 1500 or 2000 meters, so normally the CTD was on deck and secured before the ship needed to maneuver to recover the HRP. During the cruise, 169 CTD casts and 165 HRP profiles were completed (Figure 3); the details are provided in appendix B.

Another component of **SFTRE** was the deployment of a Moored Profiler (**MP**) in the area of the tracer release. The MP was deployed and recovered for us by the WHOI researchers on mooring cruises subsequent to each of ours. The MP was deployed at 13°N 55°W on February 17, 2001 and recovered April 18, 2002 during the recovery of the Guiana Abyssal Gyre Experiment (GAGE) mooring array. Unfortunately a programming error caused data logging to stop prematurely due to a full disk after 4.5 months. However, even the shorter than anticipated record allowed new insights into the thermohaline staircase phenomenon to be obtained.

This report documents the HRP and MP components of the **SFTRE**. Details of the tracer work accomplished on these cruises will be documented in a separate report. The following sections contain (in order) a list of participants for both cruises, a description of the HRP, and its data processing, a description of the MP, a description of the operations during tracer injection cruise, a narrative of the operations on the tracer sampling cruise, and some preliminary results.

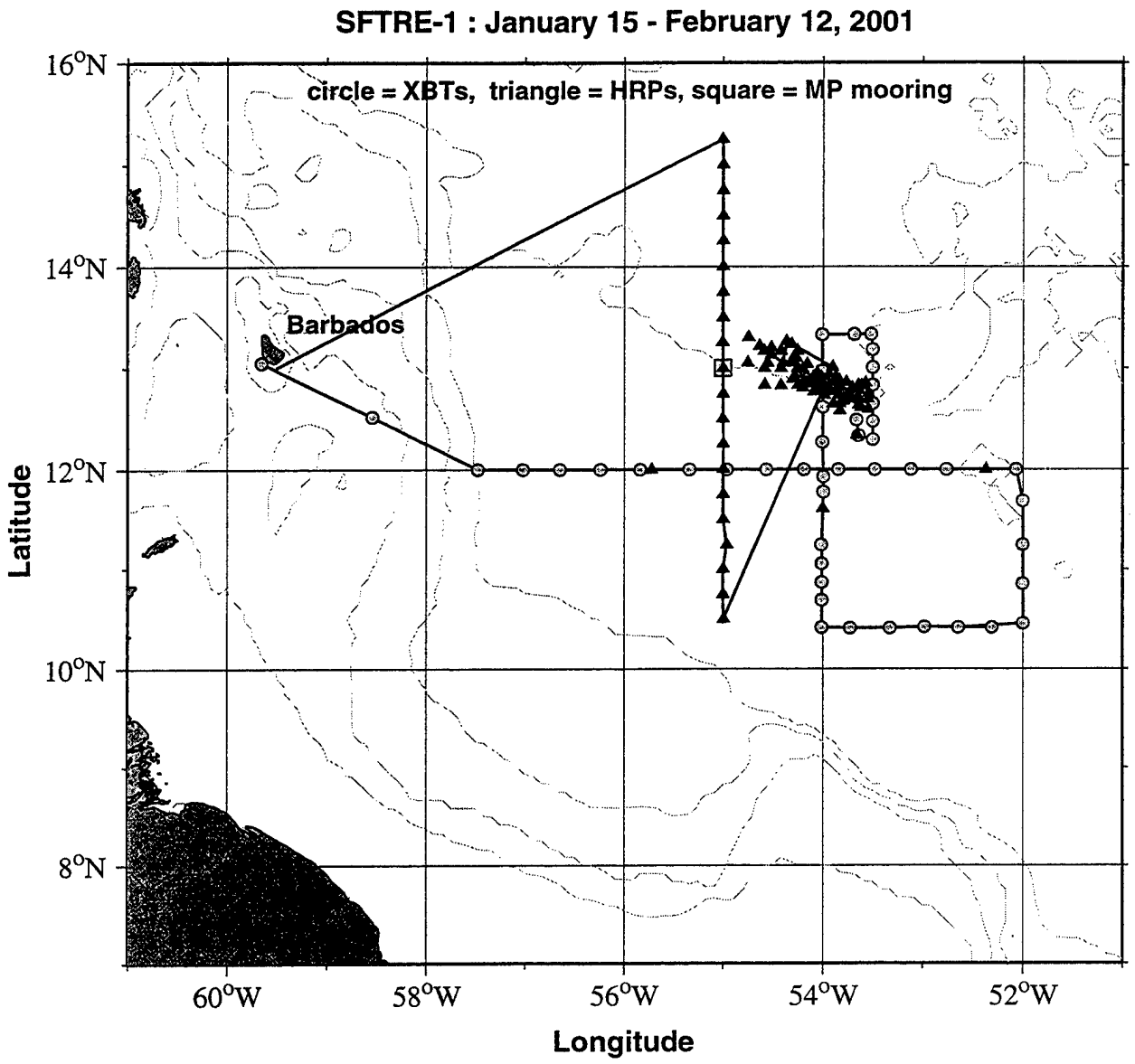

Figure 2: Chart of the *Oceanus* (OC365) cruise track. The tracer injection was centered at 12° 42'N, 53° 68'W.

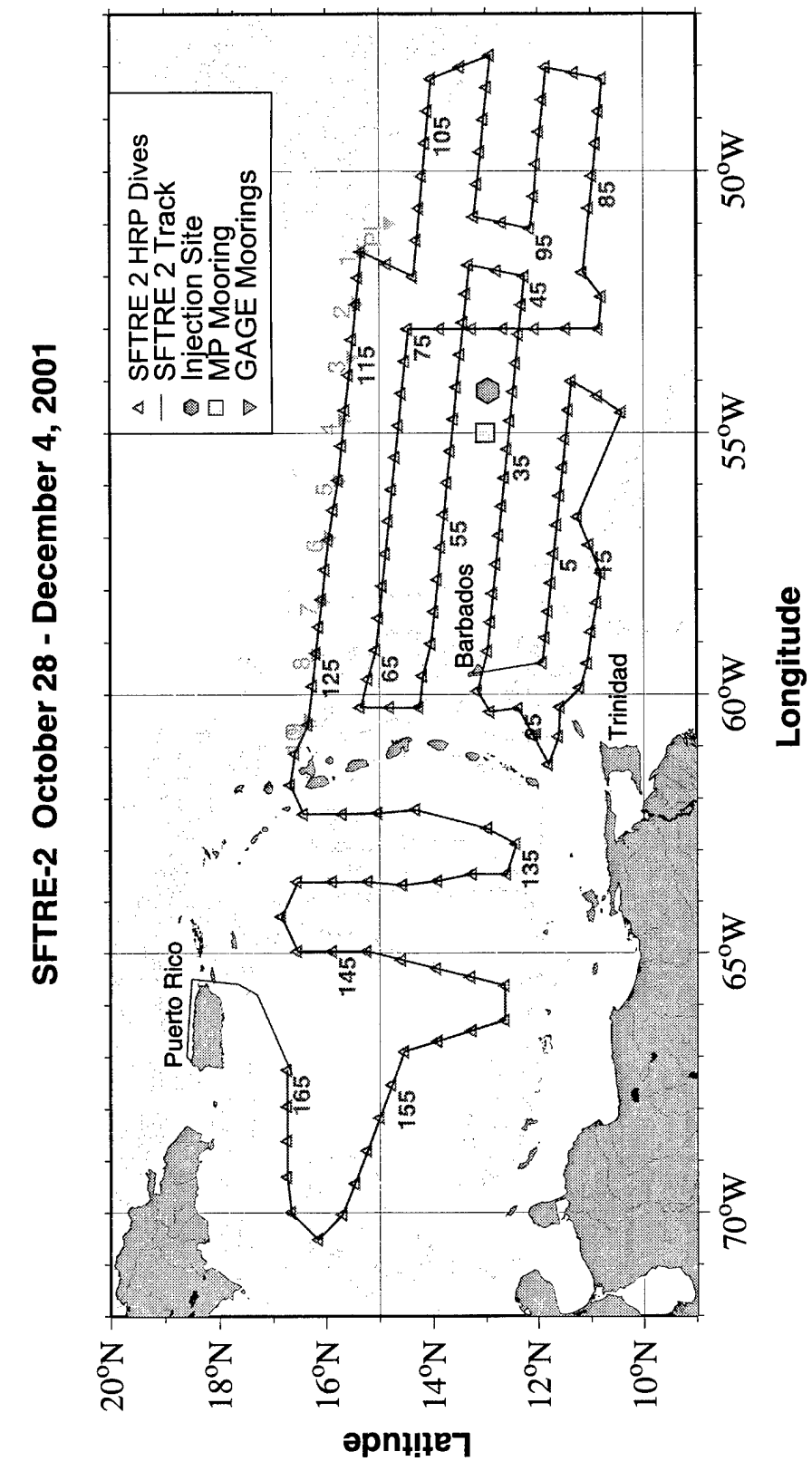

Figure 3: Chart of the *Seward Johnson* (SJ0112) cruise track. The distance is more than 6000 nautical miles.

Science Participants

Most of the personnel on the two cruises were from WHOI. The affiliation of the outside participants is listed beside their names.

Injection Cruise Participants (OC365)-

HRP Team:

Ray Schmitt (Co-chief Scientist)
John Toole
Kurt Polzin
Ellyn Montgomery
Dave Wellwood
Tom Bolmer
Tom Farrar

Tracer Team:

Jim Ledwell (Co-chief Scientist)
Terry Donoghue
Brian Guest
Cindy Sellers
Scott Birdwhistell
Stewart Sutherland (Lamont Doherty Earth Observatory)

Sampling Cruise Participants (SJ0112)-

HRP Team:

Ray Schmitt (Co-chief Scientist)
John Toole
Kurt Polzin
Ellyn Montgomery
Dave Wellwood
Tom Bolmer
Agatha deBoer (student, Florida State University)

Tracer Team:

Jim Ledwell (Co-chief Scientist)
Terry Donoghue
Cindy Sellers
Leah Houghton
Samuel Ledwell (guest investigator)
Antonio Benites (student, Universidad de Oriente, Venezuela)
Glennis Hernandez (student, Universidad de Oriente, Venezuela)
Ryan Brathwaite (government coastal planner, Barbados)

High-Resolution Profiler Description

The High Resolution Profiler (HRP) is an oceanographic instrument designed to collect fine- and microstructure data during vertical profiles. It was designed and fabricated at the Woods Hole Oceanographic Institution in the mid 1980's. The concept of an instrument equipped especially for exploring the deep ocean came from Ray Schmitt and John Toole. Engineers Dick Koehler, Ken Doherty, and Ed Mellinger made the concept a reality. A schematic of the HRP (Figure 4) shows the instrument's structure and internal components.

The operation of the HRP is controlled by an on-board "interface bus computer" (IBC) that uses the original PC 8086 chip. In order to have the computer fit into a six-inch diameter pressure case, the IBC was designed to fit on several small cards interfaced to the instrument backplane. The A/D converter and integral CTD both communicate with the computer via backplane connections. The software controlling the computer's operation is written in C and assembly language.

The HRP can be programmed to acquire data from up to 18 sensors simultaneously. The data from the sensors (including the CTD) sampled at 10 Hz is called the 'fine,' 'finescale' or 'finestructure' data. The data from the sensors sampled at 200 Hz is called 'micro' or 'microstructure.' The profiler was designed for versatility, so its configuration is determined by whichever suite of sensors is connected to the available channels. The sensor configuration that was used in SFTRE is shown below:

Fine sensors-	**A/D channel**
pressure	-
temperature	-
conductivity	-
accelerometer top X	0
accelerometer top Y	1
accelerometer bottom X	2
accelerometer bottom Y	3
acoustic current meter X velocity	4
acoustic current meter Y velocity	5
X magnetometer	6
Y magnetometer	7
A/D ground	14

Micro sensors-	**A/D channel**
differential conductivity	10
differential temperature	11
shear X	12
shear Y	13

The diagram of the sensors (Figure 5) shows their positions at the leading edge of the profiler.

To eliminate noise induced by ship motions from the measurements, the HRP operates without a cable attaching it to the ship. It is deployed, falls freely while collecting data, releases its weights and ascends to the ocean surface where it is recovered. Once on deck, the data are downloaded from instrument memory to a shipboard computer where analysis and archival occurs. At a nominal descent rate of 0.6 meters/second, a 1000-meter dive typically takes 30 minutes to descend, and another 18 to return to the surface. During the descent, one-half megabyte of fine data and two megabytes of micro data will be acquired and stored, given the above configuration.

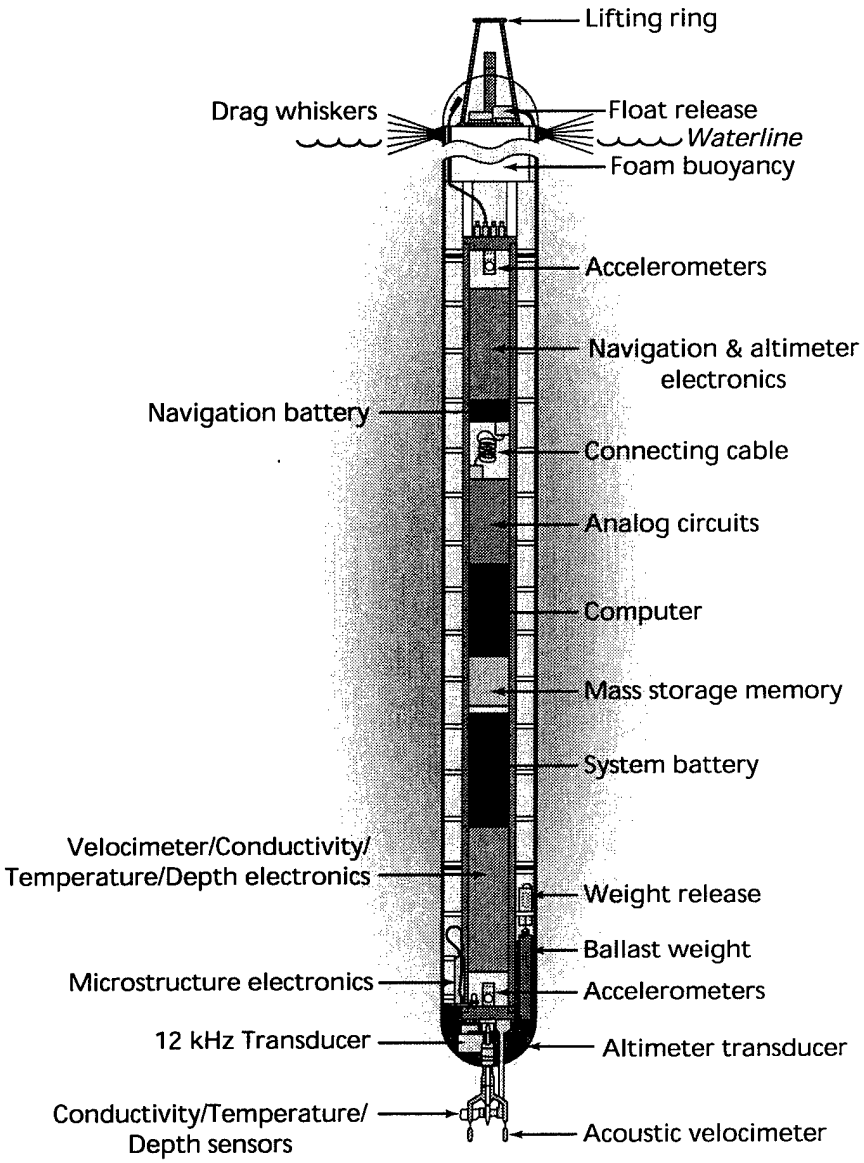

Figure 4: Schematic of the High Resolution Profiler (HRP), and its component systems.

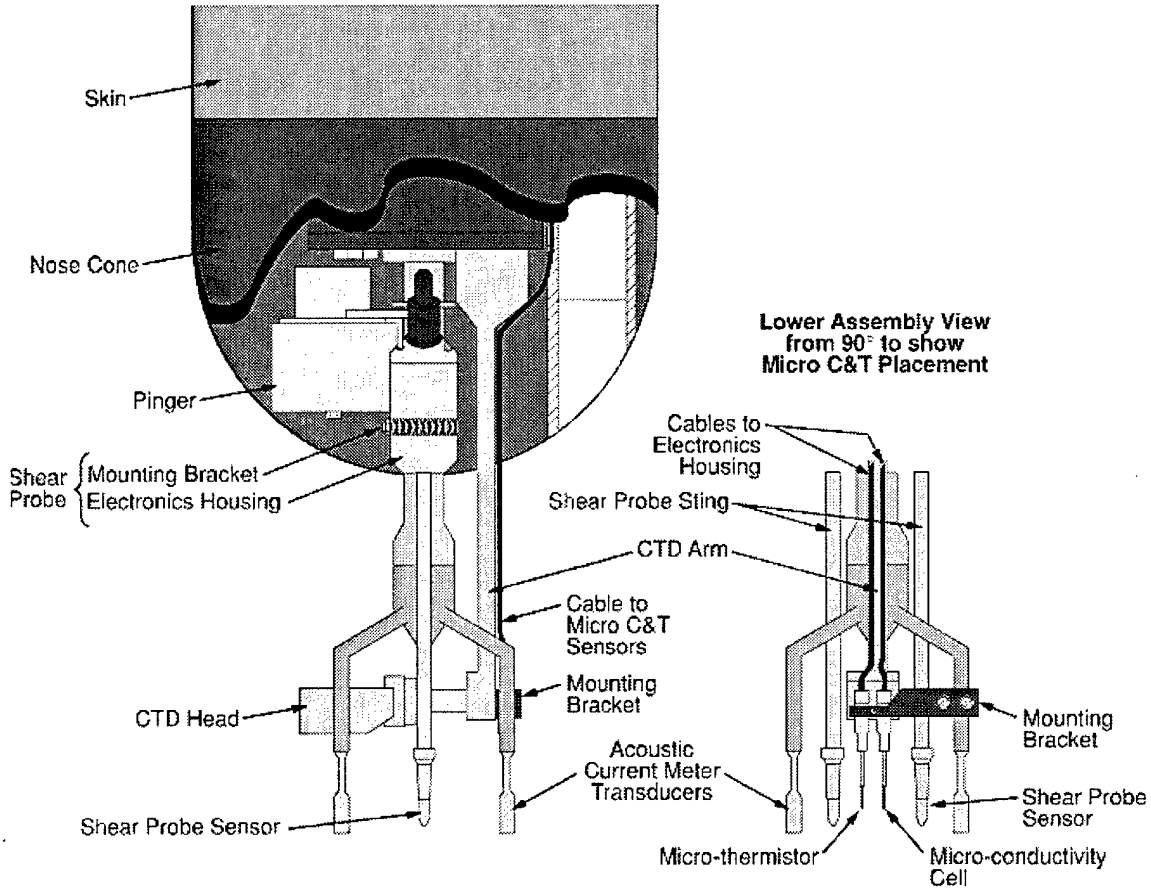

Figure 5: Diagram of the HRP sensors and mounting positions at the leading end the profiler.

For additional information on the development and use of the HRP, see the 1995 and 1988 papers by Schmitt and coauthors.

SFTRE Specific Issues

As the HRP aged, sometimes it malfunctioned in some way, despite rigorous pre-cruise testing. For this set of cruises, there were a few challenges and one success. First the success; the source of the spurious computer resets that had occurred since the battery meltdown prior to *Oceanus* 250 in May of 1998 was finally found. An area inside the pressure case had the anodizing eaten away by pooling battery acid. If the orientation of the case was such that the lower electronics rack contacted the bare metal, often as the HRP was raised for deployment, a reset of the computer occurred. Wrapping the electronics racks in Mylar before inserting them into the pressure case effectively solved this problem. The solution was implemented prior to **SFTRE-1**; so spurious resets didn't occur on either cruise.

A second issue that caused some trouble was the compass data clipping and jumping. The compass is a two-axis magnetometer on a gimbal mount within an oil-filled, sealed housing. On occasion, one axis of the magnetometer would be biased off zero, causing its signal to be clipped when values reached full-scale on the digitizer. Corrosion of the gimbal was suspected, but as the compass is a sealed unit, we couldn't be sure. Post-processing software was created to approximate and replace the clipped part of the signal.

The third issue occurred only on **SFTRE-2** and involved spikes in the velocity profiles. Spikes occurred in about 10% of the profiles, always in the shallow part (before scan 5000). We were unable to find the cause of this problem. Fortunately, on scales longer than the length of the HRP body (5 m) the relative velocity and acceleration are highly correlated. So software was developed to replace the scans for the duration of a spike in the X component of velocity with the same scans from the lower X accelerometer. When the spike was in Y, the replacement data was obtained from the lower Y accelerometer.

Most dramatically, during the recovery of **SFTRE-2** profile 13, the HRP was accidentally struck by the ship's propeller. The external damage to the plastic skin was repaired in a half day, but the pingers did not operate correctly after the accident. Fortunately both pingers pinged, which just decreased the signal level. Had neither pinger operated, we would have been in a less viable position for tracking the HRP while it was submerged. When the repairs were complete, HRP operations continued as before.

Despite the accidents and minor malfunctions, the HRP has had a long and useful career. During **SFTRE-2**, the HRP made its 1000th profile- an impressive accomplishment for the instrument and the people working with it.

HRP Data Processing

The HRP can acquire and store up to 16 MB of data during one profile. The data is stored in binary format to minimize the amount of storage space required. The first operation in the data processing sequence is offloading the data from the HRP to a computer on the ship. Due to the age of the instrument, a fast serial transfer (38.4 KB) is used instead of FTP or something more current.

The HRP currently records twelve channels of data at 10 Hz, which is recorded to one file. Profiles of temperature, salinity, and absolute velocity profiles are obtained from the 10-Hz data. Several steps are required to convert the relative velocities logged by the HRP to absolute velocity profiles. First, the accelerometer data is used to remove the nodding contamination from the relative velocities. Then the compass data is used to place the relative velocities into Cartesian coordinates. Finally a model is used to derive an ocean velocity profile, which is adjusted using the ship's ADCP data as reference, to obtain absolute velocity profiles. One set of programs unpacks the data, applies calibrations, makes the computations described above, and displays the fine-structure data.

Four channels of data are acquired at 200 Hz simultaneously with the 10-Hz data during a profile. The 200-Hz data is logged to a second, larger file. The micro data is processed with another suite of programs that filter, display and perform various signal processing tasks. The outputs quantify the processes at the smallest vertical scales, providing estimates of the rates of dissipation of thermal variance and turbulent kinetic energy.

The software for processing the HRP data processing was originally developed on Digital VAX/VMS computers, and was later ported to SGI UNIX workstations. The software employs several programming languages. Fortran, Perl, shell scripts and Matlab are used to do most of the numeric manipulation and display. A graphical user interface that controls the executing of all of these programs was developed using Tk/Tcl to simplify the HRP data conversion and analysis process. The GUI software is documented in the 1998 report by Montgomery and Bolmer.

The HRP's internal CTD was calibrated before and after **SFTRE-1**, and those calibrations were used to adjust the temperature and salinity profiles from that cruise. Prior to SFTRE-2 the CTD data did not appear to have drifted, so we did not calibrate it again. During the cruise, the calibration data from **SFTRE-1** was used. For the final adjustment, the salinity data from the HRP was fit to the best version of CTD data obtained by the tracer group.

Moored Profiler Description

The Moored Profiler (MP) was conceived to address the needs of long-term ocean sampling in a cost effective manner. Development of the MP was initiated in 1992 with grants from the U. S. National Science Foundation and the WHOI Director's Discretionary Fund. Follow-on support was obtained from the Office of Naval Research and the National Oceanic and Atmospheric Administration. The culmination of this engineering effort was an operational prototype WHOI Moored Profiler (Figure 6). The papers by Toole et al., 1999 and Doherty et al., 1999 describe the MP instrument development and sensor systems. MPs have been used successfully in numerous experimental programs since the first prototype was made. Currently, Moored Profilers are produced commercially by McLane Research Laboratories, of East Falmouth, MA.

The MP utilizes a small, battery-powered traction motor to climb up and down a standard subsurface mooring cable carrying sensors that document the water properties and currents versus depth. Depending on the design of the mooring, a MP is able to sample from just below the surface to just above the bottom with a total endurance of approximately one million meters per deployment. Complex sampling schedules are possible under control of the onboard micro-processor. MP data are presently stored internally for the duration of each deployment and downloaded after the instrument is recovered. The technology to return data in real-time via satellite and possibly modify the sampling program during a deployment is in development.

The MP used for SFTRE was deployed February 17, 2001 at 13°N, 55°W, from the R/V *Oceanus* on the cruise following ours. It was recovered on April 18, 2002 by scientists on the R/V *Knorr* while doing other mooring work in the area. The MP used in **SFTRE** was WHOI #1, instrumented with the following Falmouth Scientific (FSI) sensor systems:

EMCTD	**s/n 1314**
ACM	**s/n 1511**

This instrument was programmed to make three round trips between 100 db and 650 db every day beginning from the bottom at 0000, 0800 and 1600 Z, with a three hour wait at the upper stop before initiating each down profile. Incorrect mission planning resulted in the disk becoming filled prematurely after only 4.5 months. However, the 775 profiles that were acquired provide much of the data needed to quantify the variability in the area.

The start times of the first and last profiles are listed below:

February 17, 2001 at 2354	**profile 0**
June 27, 2001 at 0345	**profile 775**

Because of the method of deployment and startup, the first profile is always a down profile – the second profile started up on schedule at 2/18/01 0800 (it had not reached the bottom in time to start up at 0000, so waited until 0800). The last profile happens to be a down, begun after waiting three hours from the completion of the previous profile, and thus is not on an even time increment.

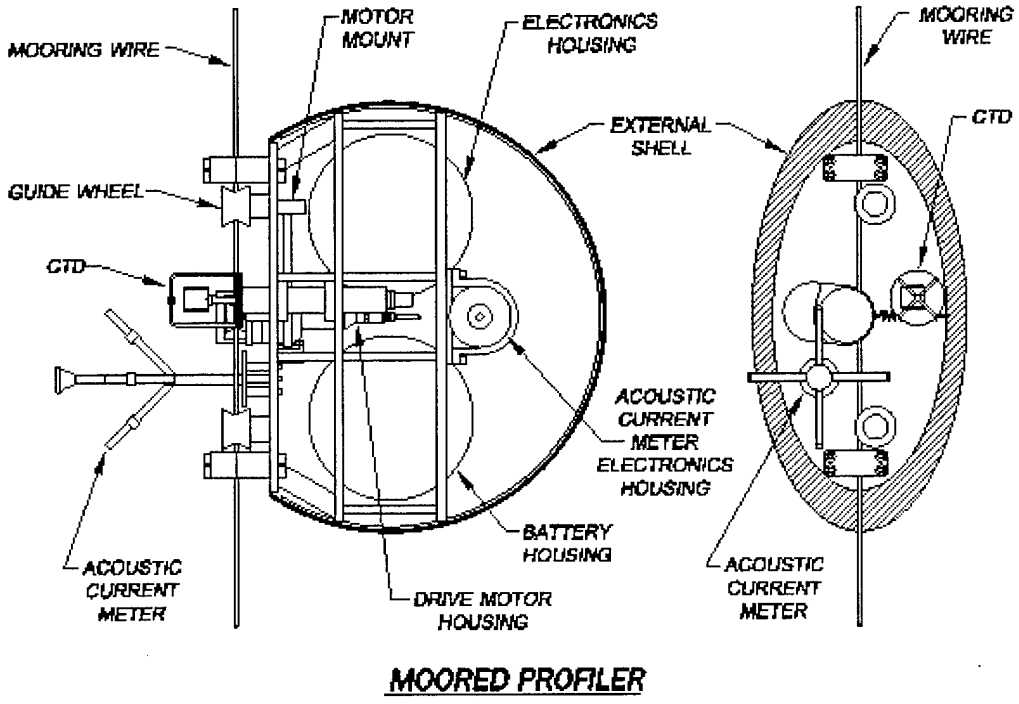

Figure 6: Schematic of the WHOI style Moored Profiler (MP).

Cruise Narrative – R/V *Oceanus* 365 (OC365)

The injection cruise took place aboard R/V *Oceanus*, cruise 365 leg 2 (leg 1 was the Woods Hole to Bridgetown transit). We were allowed to load the ship at the WHOI dock before she sailed, so the scientists could meet the ship in Barbados and depart for sea the next day (January 15, 2001), avoiding the usual headaches encountered during several days working in a foreign port.

The first work of the cruise was conducting an XBT survey to map the extent and continuity of the thermohaline staircase features. At 0300h January 16, we commenced the survey employing T7 (~800 meter) XBTs. They were launched every 2 hours, with water samples collected hourly to calibrate the ships underway thermosalinograph. During the next three days, a total of 49 XBTs were used to characterize the distribution of staircases in the potential injection region. In the two cases where an XBT was bad, a second was deployed at the position of the dud. The data obtained in this survey were used to select the location and depth of the tracer injection. The injection target was a mixed layer with a mean temperature of 10°C, centered at 12°42'N, 53°68'W. The depth of this layer varied between 370 and 410 meters.

HRP test dives and injection sled tests were interspersed with the XBTs. HRP profile 1 was made on January 16 at 1245. All sensor systems worked correctly. The tests we did at the dock showed clipping of the compass, but it was not evident on the first dive. The first injection sled test occurred at 1825h – 2143h the same day. The test identified several issues to be resolved before the actual deployment began. A second HRP profile was made on January 17 at 1216 to hone the watch's skills working with the instrument and processing the data.

The area with the thermohaline staircases is in the trade wind zone, so we experienced typical wind speeds of 20–30 kts from the east. These kicked up whitecap-topped swell of 3–5 meters. So eastbound courses pounded into the waves, northerly and southerly ones were in the troughs, and westbound courses had relatively comfortable following seas. The first week of the cruise felt pretty rough; the rest of the cruise was rough but didn't feel as bad.

The real work of the cruise, the tracer injection and HRP work began January 19. The activity schedule had the tracer group working overnight with HRP operations during the day to avoid recovering HRP in the dark. Normally, the tracer injection sled was deployed after dinner, flown overnight injecting tracer, and was recovered around breakfast time. HRP profiles to 2000 meters were made during the day while the sled was reloaded with tracer. Usually, three HRP profiles were completed between injection runs, one each at the beginning and end of the injection tows, and one nearby. Tracer streaks were injected the night of January 19, and the subsequent six nights, finishing on January 27 at 1229. Four RAFOS floats were deployed with the tracer to follow the movement of the water initially in the tracer patch. These floats were timed to surface shortly before the second cruise to suggest possible limits of the tracer and thus aid in planning the sampling strategy. Twenty-five HRP dives were completed on the days when tracer was injected at night.

At the completion of the first 28 HRP profiles, the HRP battery was not quite low enough to change in normal operations, but since the next objective was to complete nine profiles in 24 hours, we decided to change it prior to initiating the time series. The nine-station 24-hour time series surveys used an 'X' pattern, centered on the current position of the tracer patch, with each of the legs of the 'X' angled 45° to the direction of advection. The shipboard ADCP data was employed to infer the direction and rate of tracer patch advection. The center of the first survey was 12°48.40'N, 53°54.7'W. Dives 29–37 occurred between 1413 on January 27 and 1330 on January 28. The ADCP data was again used to determine the current position of the center of the patch (12°50.52'N, 53°56.87'W), and then another 'X' pattern was started. Dives 38–46 occurred between 1504 on January 28 and 1606 on January 29. Another 'X' survey centered at 12°50.52'N, 54°01.21'W was completed between 1727 on January 29 and 1526 on January 30. Since 27

profiles had occurred since the last battery change, and we had another nine-station survey planned, we changed the HRP battery again. During the last 27 profiles, the pingers had been pinging less strongly than with the first battery, and sometimes on the ascent both would transpond, instead of just the bottom one. We hoped a new battery would remedy this, but it didn't.

The center of the patch was estimated to be at 12°50.64'N, 54°07.72'W after the battery change, and then another 'X' pattern was embarked upon. After the first profile (56), examination showed the data from the Y component of the compass was clipped. This was the first occurrence of this malfunction, so we assumed that it had something to do with the new battery. The electronics were removed from the pressure case and brought inside again. We did what we could to diagnose and fix the compass, but in a metal ship, this was a difficult task. We ended up re-assembling the HRP without believing the problem was resolved. Surprisingly, the compass had returned to the way it was before dive 56 and functioned well thereafter. Dives 56–63 occurred between 2154h on January 30 and 2150 on January 31. One station at the southeast of the pattern was skipped to make up the time lost working on the HRP compass.

During the time the HRP group did the four 'X' pattern surveys described above, the tracer group dismantled and stowed the injection sled. The lab was aired for two days, then they began unpacking the sampling equipment. Due to risk of contamination, the injection apparatus can never out at the same time as the sampling gear.

To sample the tracer patch, a specialized sled combining a CTD and integrating water collection apparatus was used. In Appendix A, this vehicle is referred to as the integrating sampler (I.S.). The water samples collected over the duration of a tow are analyzed for SF6 concentration onboard the ship using a Gas Chromatograph (GC).

The first overnight run using the integrating sampler was made on February 1. The sled was towed for 12 hours, through the area where the tracer was expected. A HRP profile was made at the end of the tow, and then two more were made nearby that day. Analysis of the water collected by the sampler found concentrations of tracer that matched the levels expected based on the amounts injected. The sampling sled was towed overnight for the following five nights, with three HRP profiles completed during the days, covering various spatial patterns. HRP 88 was the last profile interspersed with towing the integrating sampler.

On February 7, CTD operations were commenced. The bottle samples from the CTD take discrete water samples, which were compared to the ones from the integrating sampler on the sled. HRP 89 was deployed when the first CTD had started its ascent.

After a simultaneous CTD cast/HRP deployment at the injection site, we steamed to 10°N, 55°W to begin a meridional section along 55°W. Station spacing was one-quarter degree. HRP profiles 90–109 comprised the section, which extended through the tracer injection area and continued to 15°15'N. CTD casts were not made with all HRP profiles – just at the sites of HRP dives 93, 97, 105, 108. The last HRP profile (109) was completed February 11 at 0412.

The lab was dismantled during the transit back to Barbados. The R/V *Oceanus* arrived in Bridgetown at 1300 on February 12. We off-loaded our gear into the containers waiting for us at the dock, and then consigned them to the agent for shipment back to Woods Hole.

The next day, we met with the scientists going on the following cruise to discuss details of the MP mooring deployment. The position for deployment was reviewed, the MP had already been programmed, and passed all the pre-deployment checks, so it was left on the *Oceanus* ready to go. Finally, the participants in SFTRE-1 were able to leave the ship knowing the injection phase of the cruise was successfully completed.

Cruise Narrative - R/V *Seward Johnson* 01-12 (SJ0112)

The science party met the ship in Bridgetown, Barbados when it arrived October 28, 2001. Since we were able to load the ship in Florida before it left for Barbados, only a day and a half were needed to prepare for the work of the cruise. The ship departed at 1800 (local) on the 29th. Due to immigration problems, the Venezuelan students had not arrived; so the cruise plan was modified to return to port one week later to pick them up.

Operations commenced south of Barbados soon after departure, with CTD profiles and chemical analysis of the water samples collected. All CTD profiles on this cruise were to 1000 meters and HRP profiles were to 1500 or 2000 meters unless otherwise stated (see Appendix B for details). The HRP group waited until daylight to do their first profile, which accompanied CTD 4. On the first profile, corrosible links for 1600 meters were installed for a dive to 1500 m. Unfortunately, one released at 1493 meters, just slightly shallower than the desired termination pressure of 1500 db. Consequently, the HRP ascended slowly until the release criteria based on time was reached and the second weight was jettisoned. Then it ascended at the expected rate and was recovered without incident. The next two profiles were to 1250 meters because the water was shallower than 1500 meters. After HRP 3 (CTD 6) we were in deep enough water to commence 2000-meter profiles. The HRP was descending faster than desired, so several chunks of syntactic foam buoyancy were added. This successfully slowed the descent rate to the desired rate of between .5 and .65 m/sec.

CTD casts with an accompanying HRP deployment became routine between October 29 and November 2. The weather was calm and balmy, so conditions were pleasant (unlike the previous cruise). The uneventful sequence of work ended at 0451 Friday November 2. Just after the midnight (local) change of watch, during the recovery of HRP 13, the ship accidentally hit the HRP with the propeller while maneuvering. Poor visibility at night, and the HRP only being partially hooked, both contributed to the incident. The HRP was recovered on a second pass, at which time we were able to assess the extent of the damage. The plastic skin and structural elements near the sensor (lower) end experienced the bulk of the trauma. Miraculously, despite the mauling, the cables, sensors and pressure case were not ruined.

We were also lucky that one of the ship's engineers was experienced in welding plastic, and was able to convert a sensor guard made of a spare section of plastic skin into a replacement segment of the instrument's cowling (Figure 7). The repairs took about 12 hours, during which time three more CTD profiles (17–19) occurred. The HRP was dangled in the water while still attached to the lifting rig after CTD 19 to test functional integrity while vertical, and while wet. The only problem seemed to be that both pingers transponded during ascent, instead of just the bottom one, resulting in a weak acoustic signal received at the ship. We tried several fixes, none of which worked, and decided to continue with HRP operations.

CTD 20 occurred on October 2 at 2130. The repaired HRP was deployed for a 1000-meter profile after the CTD was back on deck. It functioned adequately, and returned with good data, so "normal" operations were resumed. We had three more 2000-meter HRP profiles before the water depth became shallow enough to modify the dive termination depth. Two profiles (HRP 18 and 19) were made to 1600 meters without using the altimeter. It was turned on for dives 20 to 23 and obtained correct seeming ranges from the bottom each time. The altimeter was used on these primarily to exercise it, and the pressure criteria terminated the profile each time. The altimeter data collected was good, so later in the cruise when near bottom approaches were desired, we were confident of the altimeter's functionality. After dive 23 the ship moved into water deeper than 2200 meters, so the altimeter was not used.

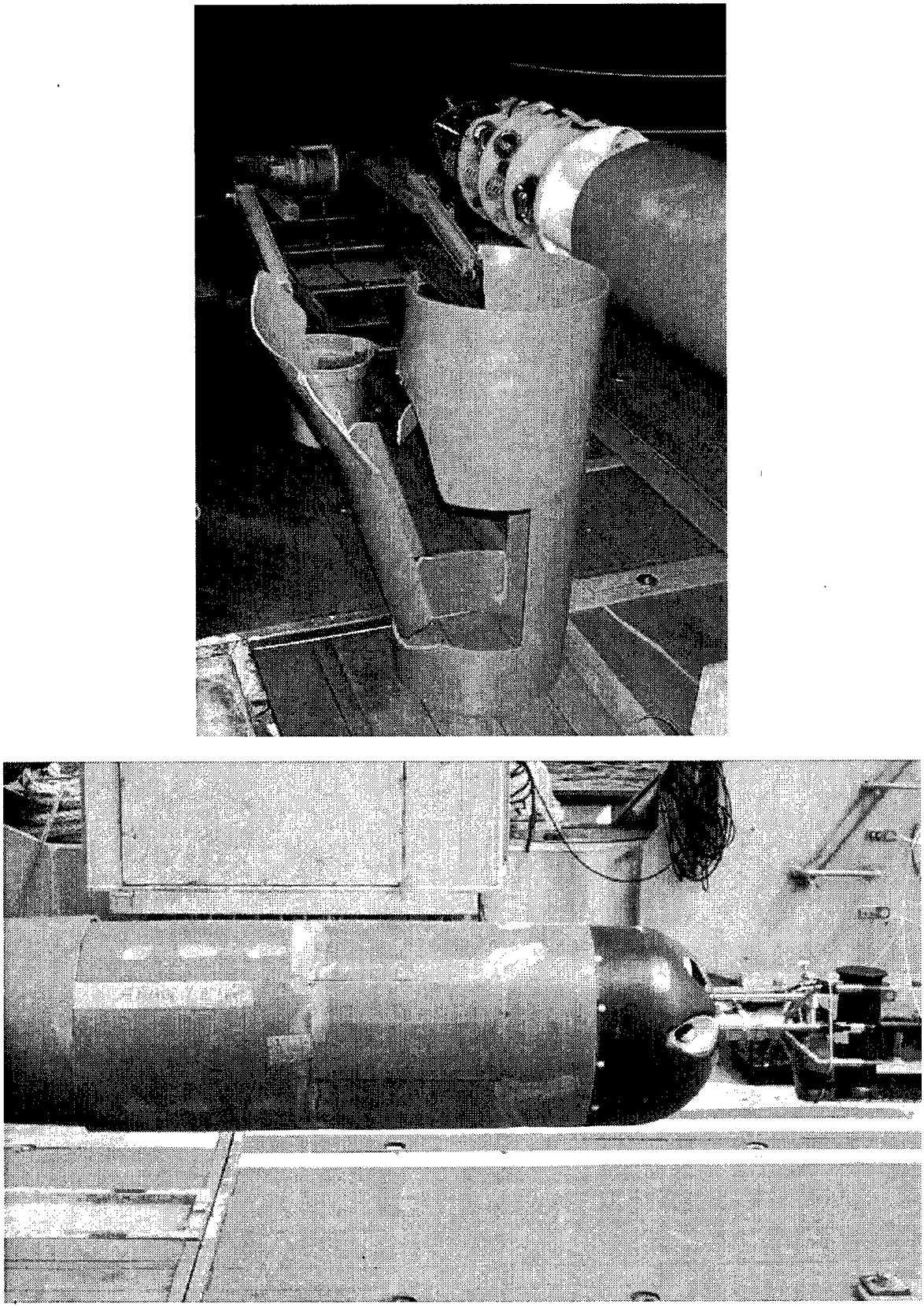

Figure 7: Photos of the damaged (top) and repaired (bottom) HRP.

The *Seward Johnson* returned to port in Barbados on the morning of November 5, to pick up two Venezuelan students, at which time the observer from Barbados disembarked. After fueling, the ship left port to head east to continue the survey. Operations were resumed on November 5 at 2114 with CTD 34 and HRP 28. The work of the cruise continued uneventfully on an easterly course for three days. During this time the problem with the pingers was resolved by accident on a profile done without the lower pinger connected at all. It was disconnected in an attempt to diagnose the source of intermittent 34.25 Hz noise in the micro-T data. After reconnecting the pinger, both operated as expected, but the source of the noise remained unknown. Eventually the source of the noise was determined to be the normal operation of the CTD. The HRP battery was changed during the transit following CTD 42 and HRP 36, so no time was lost.

Early November 8, During CTD 45 with HRP 39, the thermostat on an oven used to bake the filters used in the Gas Chromatograph (GC) malfunctioned, ruining the coil and the oven. Since tracer analyses couldn't be done, we didn't know if we'd reached the edge of the tracer patch and thus whether to continue east or turn north. Repairs to the GC were commenced while a time series of HRP profiles every three hours was begun at the site. Four additional HRPs were completed before the GC was back on line. Since tracer was detected in the samples taken at the site of the time series, we continued east. Two more stations were completed before we turned north, even though there was still a small amount of tracer found at the location of CTD 47 and HRP 45.

Two stations were made on a northerly heading en route to 13.3°N where a reciprocal line to the previous one was started heading back west. Fifteen stations (CTD 49–63, HRP 47–61) were completed along this line headed west-northwest towards Martinique. Then we went north for the next two stations, and then turned back east to continue sampling.

Between November 11 and 14, another thirteen stations (CTD 66–78, HRP 63–75) were completed paralleling the previous line. On November 13 about 0415, during CTD 68, the winch broke down when the CTD was at 900 meters. The package had to be brought up about 20 meters with the crane to get enough slack to cut the wire and transfer it to the other winch. The HRP surfaced about a half hour after the winch broke, so had to be recovered with the CTD still in the water. The CTD was eventually recovered, swapped to the other winch, and re-terminated. CTD 69 was completed at the site of the winch breakdown to obtain tracer samples at this site.

On November 15, after CTD 78, because only 25% of the tracer had been found, we headed back south to continue looking for tracer east of where we terminated the first week's survey. Two of the floats deployed on the injection cruise went further east than we'd explored, suggesting more attention was needed in that area. CTD 79–84 and HRP 76–81 were completed along the south-bound line.

The 1000th deployment of the HRP (76) was completed on the morning of November 15, 2001. One thousand profiles is an impressive number for the use of any oceanographic instrument system, and even more so for one that does it's work while not connected to the ship. Work continued as usual after this momentous occasion.

After CTD 85 and HRP 82, another seven-station line was begun starting at 52°W continuing eastward to 48°W. The second HRP battery change occurred on November 17, after HRP 85. CTD 92, HRP 88 was the last station on the southernmost leg of the eastern addition. One dive was made half way to the next line. CTDs 94-99 with HRPs 90–95 were completed on the next northerly line moving west, between November 18 and 19. One station was made half way to the next line to the north. CTDs 101–106 with HRPs 97–102 comprised the next line north made heading back east, then CTDs 108–114 and HRPs 107–111 finished the extra survey in a westerly direction on November 22. This group of stations was completed just east of the line that stopped with CTD 78, HRP 75.

We continued the survey along the line formed by the GAGE moorings. We sampled near some of these moorings to facilitate future data intercomparisons. CTDs 116–132 with HRPs 112–127 were completed along the line defined by the moorings. Profiles to the bottom were made on HRP dives 112, 114, 119, 126, and 127. A new battery was installed prior to dive 126 on November 25. The completion of these dives put us just east of Guadeloupe, near the westernmost mooring. A strong southward deep western boundary current was observed at about 1500 meters in profile 127. A suggestion of the same feature is present in profile 128, but not as strongly.

The *Seward Johnson* entered the Caribbean north of Guadeloupe on November 26. Two more full depth HRP profiles were made, one at the sill and the other on the western slope in an attempt to quantify the mixing associated with flow into the Caribbean. We had nice views of Montserrat and its volcano, Guadeloupe and Dominica that day. We were not granted clearances by all of the Caribbean nations, so were forced to work outside their territorial waters along the island chain. CTDs 134–139 with HRPs 130–135 were completed working south, and then we moved about a degree west and started north along the crest of the Aves ridge. Seven more stations (CTDs 140–146 with HRPs 136–142) were made along the ridge crest. Large amounts of tracer were found in some parts of this survey, which was encouraging since less than half the expected tracer had been found.

On November 29 we headed south again, a bit further west over the deep part of the Caribbean basin. CTDs 148–154 with HRPs 144–150 were completed. Then we changed to a north-northwesterly course for another four stations (CTDs 155–158 with HRPs 151–154) before turning northwest for another five stations (CTD 159–164, HRP 155–160) to reach our westernmost point in the survey.

In order to make our scheduled return to Puerto Rico on December 5, the ship was turned back east to start the final sampling leg late December 2. En route to port, CTDs 165–172 with HRPs 161–165 were completed. The HRP work stopped a day earlier than CTD operations in order to dismantle the equipment and pack up our lab. The CTD/tracer team remained on the ship for the transit to Florida in order to sample northward, so they worked right into port. We arrived in San Juan early on December 5, completed loading our container for return shipment from Florida, and went ashore.

In all, 172 CTD casts with chemical analysis for tracer distribution and 165 HRP profiles were completed during 35 days at sea. This was a successful trip, despite the various hardware problems encountered, and not completely delimiting the tracer map.

Preliminary Results

Thermohaline staircase features appear to persist off Barbados. WHOI investigators last studied them during the Caribbean Sheets and Layers Transects (C-SALT) program in 1985. The duration and seasonal variations of these features isn't documented, but they were observed again on a 1998 cruise (Montgomery and Guest, 1999). We found staircases easily on both **SFTRE** cruises. A profile from the tracer injection cruise (Figure 8) shows the correspondence of velocity shears to strong temperature and salinity gradients above 350 meters where the staircases are well formed, then as the steps disappear below 350 meters, so do the jumps in velocity.

The advection of the tracer patch during the injection, based on the shipboard ADCP data was to the west-northwest at about 5 cm/sec. The HRP based advection estimate is a bit higher (about 8 cm/sec), but the profiles sample much shorter duration events than the ADCP, so the results are consistent. The HRP derived absolute velocities averaged over the duration of the injection (Figure 9) show clearly that the tracer injection target pressure of nominally 380 db was in the middle of a jet.

The westward advection was fairly consistent throughout OC365, so it was surprising that two of the drifting floats released at 550 db (about 150 meters deeper than the tracer patch) surfaced after nine months hundreds of kilometers east of the deployment area. The other two floats surfaced slightly to the southeast. The floats' trajectories involved some looping and meandering, but the net movement was to the east. With this in mind, perhaps the true surprise is that there was any tracer in the Caribbean.

The ship covered an area of over 500,000 nautical miles^2 during SJ-0112 looking for the tracer. Despite the large area sampled, only 50–60% of the tracer had been found by the end of the cruise. Given that there was still tracer detected in the samples from the ends of the survey lines, the extent of the patch could not be delimited. The distribution of tracer was widespread, uneven and somewhat correlated with presence of thermohaline staircases in the eastern portion of the survey. Within the Caribbean, the tracer distribution was smoother and uncorrelated with staircases.

The HRP profiles exhibited nearly two orders of magnitude greater dissipation of thermal variance in depths with staircases (250–500 db) than in the deepest part of the profile below the staircases. Chi-t is the rate of dissipation of thermal variance, and Epsilon is the rate of dissipation of turbulent kinetic energy. The Chi-t estimates in the staircases were greater than the estimates of Epsilon in the region where the tracer was deployed suggesting that double diffusive processes may play a larger role in mixing than turbulence in this area.

The four and a half months of temperature, salinity and velocity profiles (775 total) obtained by the MP allow us to examine the time evolution of the features we observed on the deployment cruise. The velocity sensor showed consistent eastward flow and the temperature and salinity data let us track the vertical migration of the staircase features. Figure 10 shows all the temperature profiles from February 2001, successively offset by one degree to show how the depth of the layers can vary with time.

Additional analysis is required to fully understand what the collected data means. Future publications will document this work as it occurs.

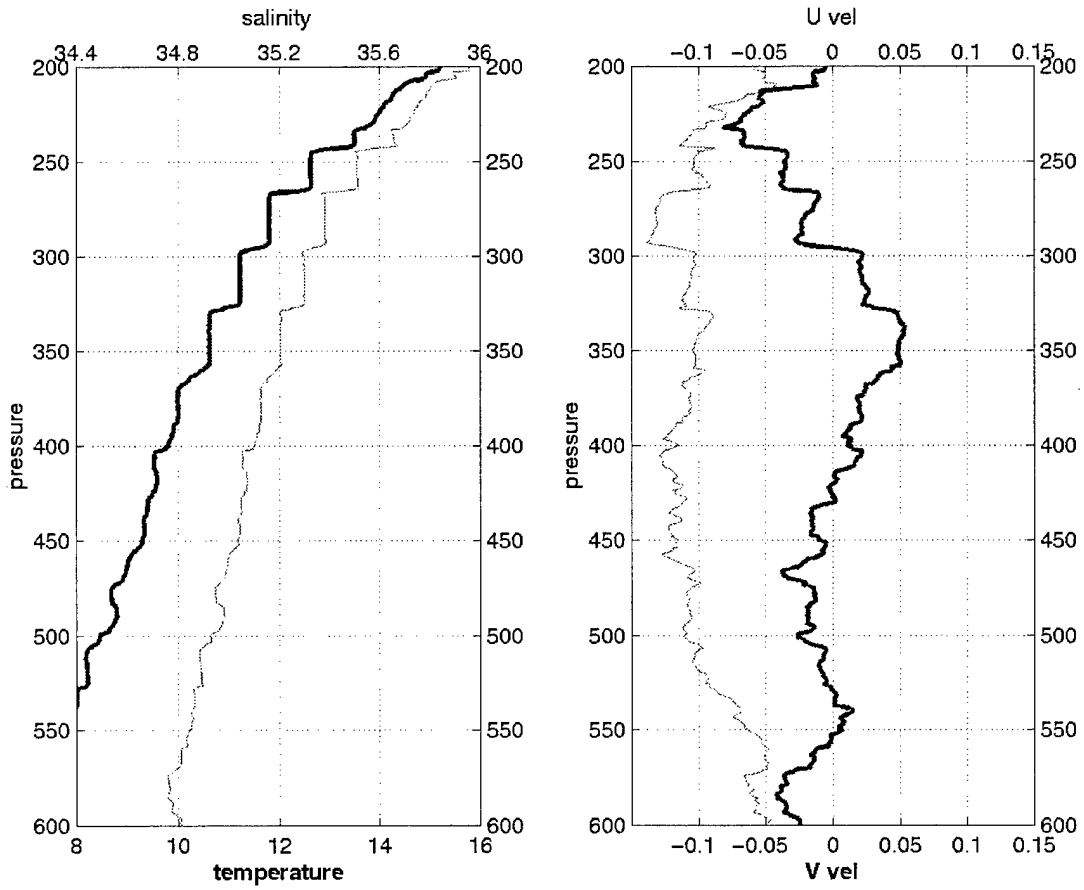

Figure 8: Data from SFTRE-1 HRP profile 33, showing staircases and how velocity shear is large in the high-gradient parts of the profile. Temperature and V velocity are shown with bold lines, salinity and U velocity use thin lines.

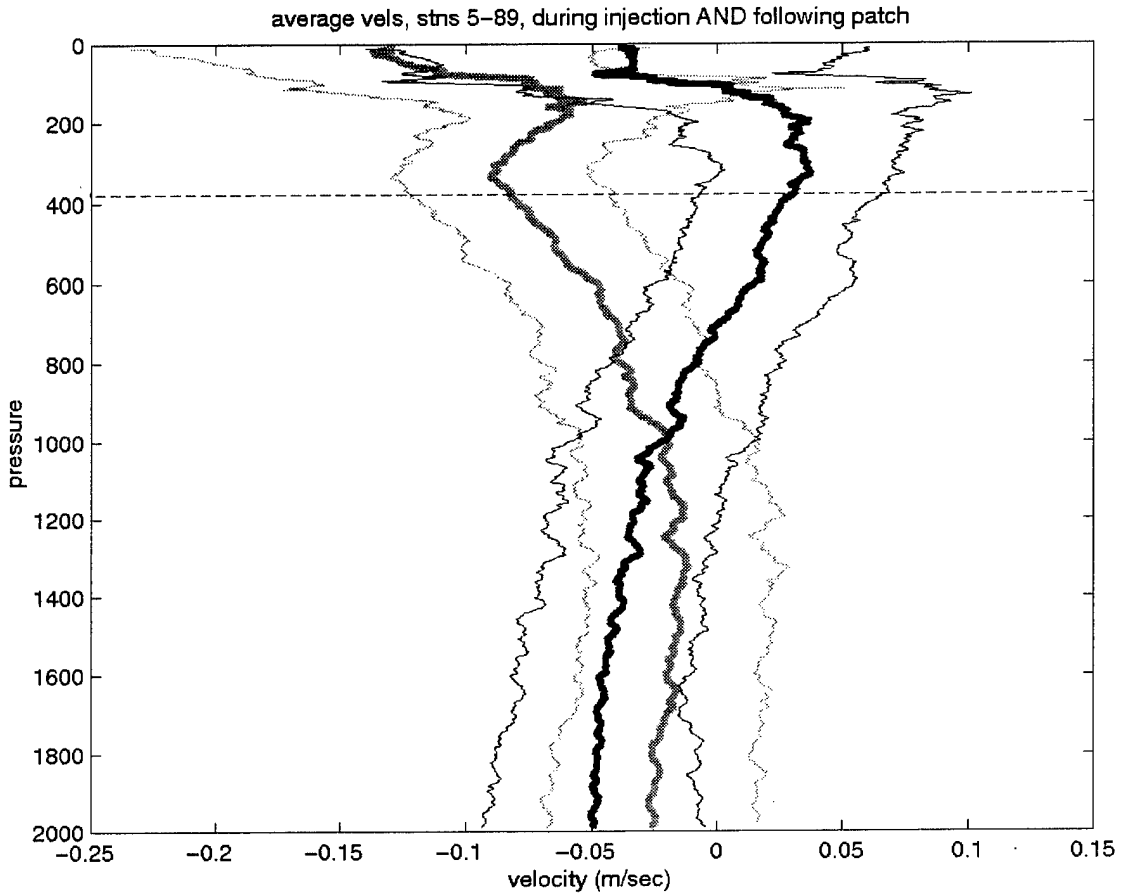

Figure 9: Plot of average HRP velocities from the profiles made during the tracer deployment and following the patch during the 'X' surveys. The dark thick line indicates the zonal component of flow where negative is west. The thick gray line shows the meridional component where positive is north. The thin lines indicate the 95% confidence interval for the means, assuming each profile was independent. The horizontal dashed line marks the mean depth of the tracer.

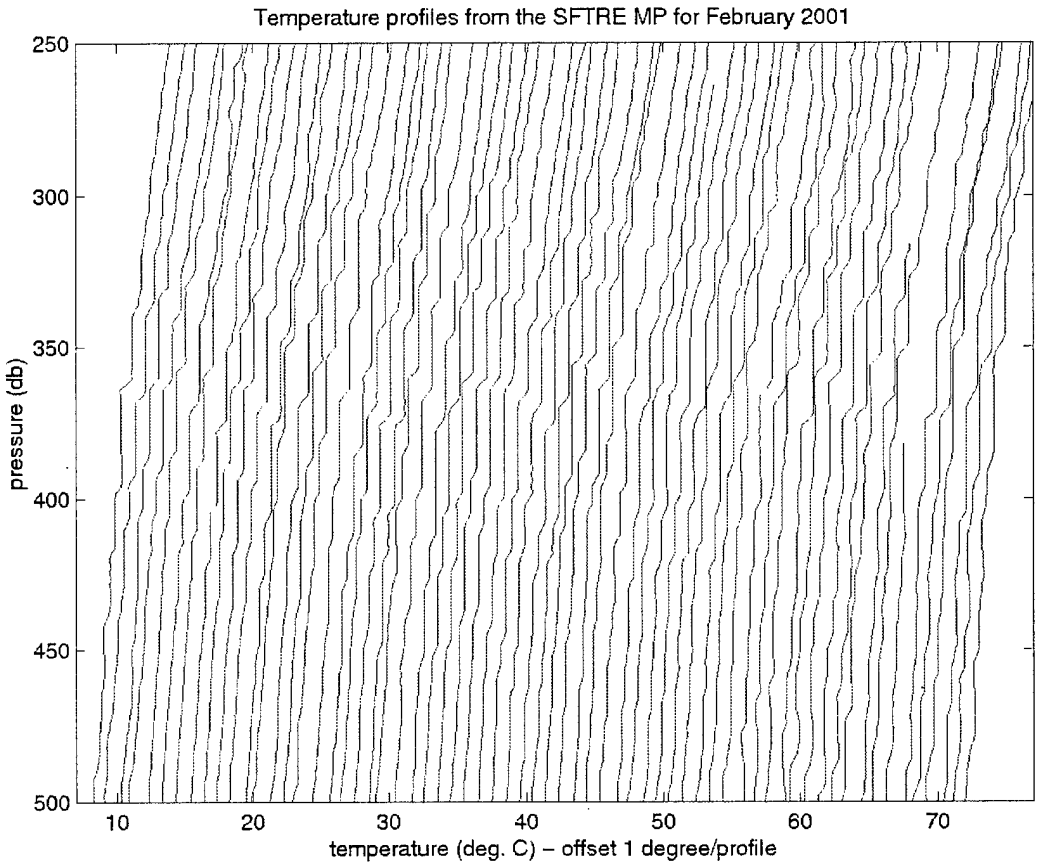

Figure 10: First 65 temperature profiles from the Moored Profiler showing the variability of layer depth shortly after OC365. Profiles are nominally four hours apart and are displayed successively offset by 1°C for visual clarity.

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Acknowledgments

The officers and crews of the R/Vs *Oceanus* and *Seward Johnson* made it possible for the work at sea to progress safely and efficiently. Both ships are a pleasure to work on, and we look forward to future voyages. Jim Ledwell provided information about the tracer component of the experiment that is summarized in this report. Ray Schmitt and John Toole provided helpful editorial comments.

Finally, we thank the National Science Foundation for their generous support of this experiment under grant #OCE-0081502.

Appendix A

SFTRE-1 Cruise Log

OC365

Barbados -> Barbados

January 15 - February 12, 2001

Date mo/da	time GMT	position Latitude(N)	Longitude(W)	what	dive# (btl #)	pmax	comments
01/15	1200	13 06.119	59 03.90	-	-	-	All science onboard
01/15	1200	13 06.119	59 03.90	-	-	-	Dep. Bridgetown
01/15	2107	12 31.07	58 32.18	XBT	2	760	test (no XBT-1)
01/16	0336	11 59.96	57 28.59	XBT	3	760	steps!
01/16	0400	11 59.98	57 23.92	SSS	A-1	-	salt sample
01/16	0500	11 59.98	57 12.01	SSS	A-2	-	salt sample
01/16	0600	11 59.99	57 01.16	XBT	4	760	
01/16	0600	11 59.99	57 01.16	SSS	A-3	-	salt sample
01/16	0655	11 59.97	56 50.48	SSS	A-4	-	salt sample
01/16	0800	11 59.9848	56 38.9037	XBT	6	760	no xbt 5
01/16	0800	11 59.9848	56 38.9037	SSS	A-5	-	-
01/16	0915	11 59.984	56 23.248	SSS	A-6	-	-
01/16	1000	11 59.9732	56 14.2646	XBT	7	760	-
01/16	1000	11 59.9732	56 14.2646	SSS	A-7	-	-
01/16	1011	- -	- -	-	-	-	start HRP runtimer
01/16	1100	11 59.975	56 02.670	SSS	A-8	-	-
01/16	1130	- -	- -	-	-	-	failed r.t. test
01/16	1200	11 59.9811	55 50.1418	XBT	8	760	-
01/16	1200	11 59.9811	55 50.1418	SSS	A-9	-	-
01/16	1245	11 59.9089	55 43.1498	HRP	1	1600	HRP away
01/16	1321	- -	- -	-	-	-	weights dropped
01/16	1341	11 59.89	55 42.85	HRP	1	1600	HRP aboard
01/16	1403	12 00.005	55 41.780	SSS	A-10	-	-
01/16	1501	11 59.98	55 30.86	SSS	A-11	-	-
01/16	1600	11 59.99	55 19.86	XBT	9	760	-
01/16	1602	11 59.99	55 19.29	SSS	A-12	-	-
01/16	1704	11 59.99	55 07.46	SSS	A-13	-	-
01/16	1758	12 00.00	54 57.40	XBT	10	760	-
01/16	1800	12 00.00	54 57.00	SSS	A-14	-	-
01/16	1825	11 59.93	54 56.27	-	-	-	inj. sled test 1
01/16	1902	11 59.90	54 55.46	SSS	A-15	-	-
01/16	2143	12 00.81	54 52.12	-	-	-	sled aboard
01/16	2304	11 59.96	54 44.42	SSS	A-16	-	-
01/16	2359	11 59.97	54 33.87	XBT	11	760	-
01/17	0005	11 59.95	54 32.77	SSS	A-17	-	-
01/17	0105	11 59.97	54 21.58	SSS	A-18	-	-
01/17	0202	11 59.96	54 11.39	XBT	12	760	-
01/17	0206	11 59.98	54 10.64	SSS	A-19	-	-
01/17	0300	11 59.96	54 01.36	SSS	A-20	-	-
01/17	0400	11 59.9598	53 50.6535	XBT	13	760	-
01/17	0401	11 59.9598	53 50.6535	SSS	A-21	-	-
01/17	0500	11 59.944	53 40.30	SSS	A-22	-	-
01/17	0600	11 59.9831	53 28.9743	XBT	14	760	-
01/17	0601	11 59.9831	53 28.9743	SSS	A-23	-	-
01/17	0700	11 59.96	53 18.22	SSS	A-24	-	-
01/17	0800	11 59.9634	53 07.2017	XBT	15	760	-

Date mo/da	time GMT	position Latitude(N)	Longitude(W)	what	dive# (btl #)	pmax	comments
01/17	0801	11 59.9634	53 07.2017	SSS	A-25	-	-
01/17	0900	11 59.9523	52 56.6750	SSS	A-26	-	-
01/17	1000	11 59.9125	52 45.5736	XBT	16	760	-
01/17	1001	11 59.9125	52 45.5736	SSS	A-27	-	-
01/17	1100	11 59.93	52 34.26	SSS	A-28	-	-
01/17	1200	11 59.915	52 23.6826	SSS	K-1	-	-
01/17	1216	11 59.92	52 22.2305	HRP	2	2000	HRP away
01/17	1400	11 59.641	52 21.903	HRP	2	-	HRP aboard
01/17	1500	11 59.892	52 14.460	SSS	K-2	-	-
01/17	1600	11 59.8821	52 03.8912	XBT	17	760	-
01/17	1603	11 59.8821	52 03.38	SSS	K-3	-	-
01/17	1627	11 58.25	52 00.00	-	-	-	turn south
01/17	1700	11 52.06	52 00.01	SSS	K-4	-	-
01/17	1758	11 41.16	52 00.02	XBT	18	760	-
01/17	1759	11 40.99	52 00.02	SSS	K-5	-	-
01/17	1905	11 28.48	52 00.00	SSS	K-6	-	-
01/17	1927	11 28.16	51 59.71	-	-	-	Sled tests
01/17	2300	11 26.26	51 59.96	SSS	K-7	-	-
01/17	2359	11 14.53	52 00.01	XBT	19	760	-
01/18	0003	11 13.78	52 00.01	SSS	K-8	-	-
01/18	0104	11 02.06	52 00.03	SSS	K-9	-	-
01/18	0200	10 51.62	51 59.87	SSS	K-10	-	-
01/18	0201	10 51.19	51 59.86	XBT	20	760	-
01/18	0307	10 38.20	51 59.65	SSS	K-11	-	-
01/18	0400	10 28.32	51 59.56	XBT	21	-	DUD!
01/18	0402	10 27.97	51 59.56	SSS	K-12	-	-
01/18	0404	10 27.58	51 59.56	XBT	22	760	re-shoot 21!
01/18	0430	- -	- -	-	-	-	turn west
01/18	0500	10 25.069	52 07.136	SSS	K-13	-	-
01/18	0600	10 25.0749	52 18.5866	XBT	23	760	-
01/18	0600	10 25.0749	52 18.5866	SSS	K-14	-	-
01/18	0701	10 25.128	52 28.506	SSS	K-15	-	-
01/18	0800	10 24.9422	52 38.3650	XBT	24	760	-
01/18	0800	10 24.9422	52 38.3650	SSS	K-16	-	-
01/18	0900	10 25.1600	52 48.0178	SSS	K-17	-	-
01/18	1000	10 25.2584	52 58.7028	XBT	25	760	-
01/18	1002	10 25.2584	52 58.7028	SSS	K-18	-	-
01/18	1101	10 24.9015	53 09.0406	SSS	K-19	-	-
01/18	1200	10 24.878	53 19.830	XBT	26	760	-
01/18	1200	10 24.878	53 19.830	SSS	K-20	-	-
01/18	1301	10 24.6404	53 32.0558	SSS	K-21	-	-
01/18	1400	10 24.6804	53 43.7022	XBT	27	760	-
01/18	1400	10 24.6804	53 43.7022	SSS	K-22	-	-
01/18	1501	10 24.3374	53 56.1476	SSS	K-23	-	-
01/18	1523	10 24.24	54 00.69	-	-	-	turn north
01/18	1525	10 24.9572	54 00.6975	XBT	28	760	-
01/18	1600	10 30.93	54 00.61	SSS	K-24	-	-
01/18	1700	10 41.62	54 00.69	XBT	29	760	-
01/18	1700	10 41.62	54 00.69	SSS	K-25	-	-
01/18	1800	10 52.21	54 00.60	XBT	30	760	-
01/18	1800	10 52.21	54 00.60	SSS	K-26	-	-
01/18	1900	11 03.33	54 00.70	XBT	31	760	-
01/18	1900	11 03.33	54 00.70	SSS	K-27	-	-
01/18	1959	11 14.49	54 00.77	SSS	K-28	-	-

Date mo/da	time GMT	position Latitude(N)	Longitude(W)	what	dive# (btl #)	pmax	comments
01/18	2000	11 14.61	54 00.77	XBT	32	760	-
01/18	2107	11 26.98	54 00.64	SSS	A-1	-	-
01/18	2225	11 36.40	54 00.16	HRP	3	2000	HRP away
01/19	0003	11 36.72	54 00.16	HRP	3	-	HRP onboard
01/19	0009	11 36.45	53 59.97	SSS	A-2	-	-
01/19	0101	11 45.34	53 59.79	SSS	A-3	-	-
01/19	0106	11 46.51	53 59.81	XBT	33	760	-
01/19	0201	11 55.52	53 59.79	XBT	34	760	-
01/19	0204	11 56.12	53 59.79	SSS	A-4	-	-
01/19	0307	12 07.06	54 00.40	SSS	A-5	-	-
01/19	0400	12 16.08	54 00.33	XBT	35	760	-
01/19	0400	12 16.08	54 00.33	SSS	A-6	-	-
01/19	0500	12 26.804	53 59.998	SSS	A-7	-	-
01/19	0600	12 37.123	53 59.963	XBT	36	760	-
01/19	0600	12 37.123	53 59.963	SSS	A-8	-	-
01/19	0700	12 47.594	54 00.081	SSS	A-9	-	-
01/19	0800	12 58.364	54 11.174	XBT	37	760	-
01/19	0800	12 58.364	54 11.174	SSS	A-10	-	-
01/19	0900	13 08.9848	54 00.2595	SSS	A-11	-	-
01/19	1000	13 19.6500	54 00.3628	XBT	38	760	-
01/19	1000	13 19.6500	54 00.3628	SSS	A-12	-	-
01/19	1003	13 20.3854	54 00.33749	-	-	-	turn east
01/19	1100	13 20.0054	53 51.4822	SSS	A-13	-	-
01/19	1200	13 20.0257	53 41.3463	XBT	39	760	-
01/19	1200	13 20.0257	53 41.3463	SSS	A-14	-	-
01/19	1300	13 20.0057	53 30.9920	XBT	40	760	-
01/19	1301	13 20.0057	53 30.9920	SSS	A-15	-	-
01/19	1301	13 19.015	53 30.0500	-	-	-	turn south
01/19	1400	13 10.9971	53 30.0426	XBT	41	760	-
01/19	1400	13 10.9971	53 30.0426	SSS	A-16	-	-
01/19	1500	13 00.4713	53 30.0412	XBT	42	760	-
01/19	1500	13 00.4713	53 30.0412	SSS	A-17	-	-
01/19	1559	12 50.0099	53 30.0427	XBT	43	760	-
01/19	1603	12 49.42	53 30.04	SSS	A-18	-	-
01/19	1700	12 39.2927	53 30.0556	XBT	44	760	-
01/19	1700	12 39.2927	53 30.0556	SSS	A-19	-	-
01/19	1800	12 28.6286	53 30.0308	XBT	45	760	-
01/19	1803	12 28.2167	53 30.0313	SSS	A-20	-	-
01/19	1858	12 18.42	53 30.03	SSS	A-21	-	-
01/19	1859	12 18.17	53 30.4	XBT	46	-	dud!
01/19	1902	12 17.6765	53 30.302	XBT	47	-	-
01/19	1910	12 16.5	53 30.03	-	-	-	turn northwest
01/19	1959	12 20.011	53 38.1020	SSS	A-22	-	-
01/19	2002	12 20.1508	53 38.7398	XBT	48	-	-
01/19	2016	12 20.51	53 39.96	HRP	4	2000	HRP away
01/19	2138	12 20.43	53 40.11	HRP	4		HRP onboard
01/19	2253	12 29.5397	53 40.0901	XBT	49	760	last XBT
01/20	-	- -	- -	INJ	-	-	injection sled tests
01/20	-	- -	- -	INJ	-	-	sled deployed
01/20	1254	12 41.7490	53 40.2299	INJ	-	-	sled recovered
01/20	1322	12 41.4899	53 40.0575	HRP	5	1999	HRP away
01/20	1502	12 41.499	53 40.297	HRP	5	-	HRP onboard
01/20	1732	12 38.38	53 39.05	HRP	6	2000	HRP away
01/20	1909	12 38.4240	53 39.3861	HRP	6	-	HRP onboard

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01/20	2021	12 34.8995	53 34.9035	INJ			sled deployed
01/21	1302	12 46.6085	53 38.7809	HRP	7	2000	HRP away
01/21	1310	12 46.6920	53 38.6470	INJ			sled recovered
01/21	1433	12 46.569	53 38.833	HRP	7	-	HRP onboard
01/21	1540	12 43.8577	53 40.9312	HRP	8	2000	HRP away
01/21	1725	12 43.8545	53 41.2441	HRP	8	-	HRP onboard
01/21	1827	12 41.2525	53 38.4314	HRP	9	2000	HRP away
01/21	2001	12 41.2871	53 38.5142	HRP	9	-	HRP onboard
01/21	2034	12 41.251	53 38.12	INJ			sled deployed
01/22	0958	12 51.2935	53 34.6376	HRP	10	2000	HRP away
01/22	1100	- -	- -	INJ	-		sled recovered
01/22	1147	12 51.2966	53 34.7561	HRP	10	-	HRP onboard
01/22	1413	12 45.3164	53 32.8164	HRP	11	2000	HRP away
01/22	1548	12 45.209	53 32.885	HRP	11	-	HRP onboard
01/22	1700	12 41.9282	53 33.0761	HRP	12	2000	HRP away
01/22	1834	12 41.8505	53 33.2467	HRP	12	-	HRP onboard
01/22	1945	12 35.7554	53 33.1321	HRP	13	2000	HRP away
01/22	2114	12 35.7168	53 33.2075	HRP	13	-	HRP onboard
01/22	2216	12 36.8452	53 37.8580	HRP	14	2000	HRP away
01/22	2346	12 36.8299	53 33.9598	HRP	14	-	HRP onboard
01/23	-	- -	- -	INJ	-		sled deployed
01/23	-	- -	- -	INJ	-		sled recovered
01/23	1514	12 49.6159	53 38.8806	HRP	15	2000	HRP away
01/23	1703	12 49.4993	53 38.9981	HRP	15	-	HRP onboard
01/23	1822	12 48.4044	53 42.5601	HRP	16	2000	HRP away
01/23	1955	12 49.3991	53 42.7316	HRP	16	-	HRP onboard
01/23	2104	12 41.9461	53 43.4328	HRP	17	2000	HRP away
01/23	2234	12 41.9789	53 43.5217	HRP	17	-	HRP onboard
01/23	2321	12 37.69	53.43.31	INJ	-		sled deployed
01/24	1359	12 49.5223	53 37.1978	HRP	18	2000	HRP away
01/24	1408	12 49.6211	53 37.0744	INJ	-		sled recovered
01/24	1359	12 49.442	53 37.236	HRP	18	-	HRP onboard
01/24	1655	12 44.7351	53 46.7369	HRP	19	2000	HRP away
01/24	1826	12 44.6280	53 46.8096	HRP	19	-	HRP onboard
01/24	1958	12 40.2916	53 48.0201	HRP	20	2000	HRP away
01/24	2127	12 40.2482	53 48.1123	HRP	20	-	HRP onboard
01/24	2135	12 40.4209	53 47.9898	INJ	-		sled deployed
01/24	2359	12 42.0165	53 47.8651	INJ	-		sled recovered
01/24	-	- -	- -	INJ	-		(fix plugged orifice)
01/25	0031	12 42.4792	53 47.7139	INJ	-		sled in again
01/25	1128	12 52.1939	53 45.2200	INJ	-		sled recovered
01/25	1256	12 45.0681	53 50.0323	HRP	21	2000	HRP away
01/25	1423	12 45.008	53 50.061	HRP	21	-	HRP onboard
01/25	1521	12 38.9084	53 50.1730	HRP	22	2000	HRP away
01/25	1651	12 38.7931	53 50.2024	HRP	22	-	HRP onboard
01/25	1800	12 34.9900	53 50.0851	HRP	23	2000	HRP away
01/25	1931	12 34.8613	53 50.2061	HRP	23	-	HRP onboard
01/25	2041	12 38.9458	53 53.9478	HRP	24	2000	HRP away
01/25	2211	12 38.9301	53 54.0381	HRP	24	-	HRP onboard
01/25	2345	12 44.0978	53 53.4172	INJ	-		sled deployed
01/26	1110	12 51.6448	53 46.1475	HRP	25	2000	HRP away
01/25	1120	12 51.7	53 45.9	INJ	-		sled recovered
01/26	1237	12 51.632	53 46.292	HRP	25	-	HRP onboard
01/26	1352	12 51.5485	53 53.9979	HRP	26	2000	HRP away

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01/26	1520	12 51.529	53 54.102	HRP	26	-	HRP onboard
01/26	1622	12 48.6046	53 51.0757	HRP	27	2000	HRP away
01/26	1752	12 48.5120	53 51.1451	HRP	27	-	HRP onboard
01/26	1857	12 45.4556	53 48.0184	HRP	28	2000	HRP away
01/26	2028	12 45.3266	53 48.0746	HRP	28	-	HRP onboard
01/26	2206	12 43.0291	53 51.0340	INJ	-		sled deployed
01/27	1229	12 54.6047	53 56.0157	INJ	-		sled recovered
							* last injection *
01/27	1230	12 54.6047	53 56.0157	-	-	-	**new HRP battery**
01/27	1413	12 52.7144	53 59.1571	HRP	29	2000	HRP away
							1st in pattern 1
01/27	1542	12 52.690	53 59.272	HRP	29	-	HRP onboard
01/27	1646	12 50.3704	53 57.2131	HRP	30	2000	HRP away
01/27	1810	12 50.2505	53 57.3015	HRP	30	-	HRP onboard
01/27	1918	12 48.4140	53 54.8167	HRP	31	2000	HRP away
01/27	2049	12 48.3521	53 54.9569	HRP	31	-	HRP onboard
01/27	2154	12 46.2877	53 52.5664	HRP	32	2000	HRP away
01/27	2322	12 46.1812	53 52.7983	HRP	32	-	HRP onboard
01/28	0021	12 44.1673	53 50.4059	HRP	33	2000	HRP away
01/28	0154	12 44.1303	53 50.5820	HRP	33	-	HRP onboard
01/28	0410	12 52.6420	53 50.4439	HRP	34	2000	HRP away
01/28	0551	12 52.533	53 50.630	HRP	34	-	HRP onboard
01/28	0649	12 50.6104	53 52.5701	HRP	35	2000	HRP away
01/28	0819	12 50.532	53 52.646	HRP	35	-	HRP onboard
01/28	0934	12 46.1805	53 56.8832	HRP	36	2000	HRP away
01/28	1104	12 46.010	53 57.005	HRP	36	-	HRP onboard
01/28	1201	12 44.1579	53 59.1350	HRP	37	2000	HRP away
01/28	1330	12 44.127	53 59.293	HRP	37	-	HRP onboard
01/28	1504	12 54.7328	54 01.1780	HRP	38	2000	HRP away
							1st in pattern 2
01/28	1639	12 54.7220	54 01.4133	HRP	38	-	HRP onboard
01/28	1827	12 52.6319	53 59.1333	HRP	39	2000	HRP away
01/28	1957	12 52.5559	53 59.2416	HRP	39	-	HRP onboard
01/28	2058	12 50.5197	53 56.8762	HRP	40	2000	HRP away
01/28	2226	12 50.4730	53 57.0350	HRP	40	-	HRP onboard
01/28	2334	12 48.4126	53 54.7038	HRP	41	2000	HRP away
01/29	0118	12 48.3754	53 54.9343	HRP	41	-	HRP onboard
01/29	0259	12 46.281	53 52.534	HRP	42	2000	HRP away
01/29	0439	12 46.230	53 52.660	HRP	42	-	HRP onboard
01/29	0554	12 54.767	53 52.566	HRP	43	2000	HRP away
01/29	0741	12 54.620	53 52.805	HRP	43	-	HRP onboard
01/29	0847	12 52.663	53 54.678	HRP	44	2000	HRP away
01/29	1018	12 52.481	53 54.744	HRP	44	-	HRP onboard
01/29	1120	12 48.4148	53 59.0362	HRP	45	2000	HRP away
01/29	1249	12 48.296	53 59.156	HRP	45	-	HRP onboard
01/29	1426	12 46.311	54 01.257	HRP	46	2000	HRP away
01/29	1606	12 46.189	54 01.4383	HRP	46	-	HRP onboard
01/29	1727	12 54.6789	54 05.6550	HRP	47	2000	HRP away
							1st in pattern 3
01/29	1908	12 54.4406	54 05.8726	HRP	47	-	HRP onboard
01/29	2007	12 52.6396	54 03.4128	HRP	48	2000	HRP away
01/29	2141	12 52.5207	54 03.5689	HRP	48	-	HRP onboard
01/29	2238	12 50.5208	54 01.2518	HRP	49	2000	HRP away
01/30	0005	12 50.4781	54 01.4044	HRP	49	-	HRP onboard

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01/30	0106	12 48.3922	53 59.0844	HRP	50	2000	HRP away
01/30	0239	12 48.3860	53 59.2498	HRP	50	-	HRP onboard
01/30	0337	12 46.2807	53 56.9049	HRP	51	2000	HRP away
01/30	0512	12 46.215	53 57.045	HRP	51	-	HRP onboard
01/30	0620	12 54.7971	53 56.9206	HRP	52	2000	HRP away
01/30	0752	12 54.605	53 57.036	HRP	52	-	HRP onboard
01/30	0901	12 52.6414	53 59.0379	HRP	53	2000	HRP away
01/30	1029	12 52.554	53 59.081	HRP	53	-	HRP onboard
01/30	1135	12 48.6414	54 03.3895	HRP	54	2000	HRP away
01/30	1245	12 48.371	54 03.511	HRP	54	-	HRP onboard
01/30	1359	12 46.2520	54 05.6083	HRP	55	2000	HRP away
01/30	1526	12 46.307	54 05.713	HRP	55	-	HRP onboard
01/30	1615	12 46.400	54 06.523	-	-	-	**new HRP battery**
01/30	1942	12 58.3864	54 12.0698	INJ	-	-	start integrating sampler (I.S.) runs
01/30	2154	12 56.88	54 12.06	HRP	56	2000	HRP away
01/30	2235	12 56.7762	54 12.2422	HRP	56	-	HRP onboard
01/31	0000	- -	- -	-	-	-	try to fix HRP compass-X
01/31	0333	- -	- -	-	-	-	reassemble HRP
01/31	0441	12 54.7651	54 10.0043	HRP	57	2000	HRP away
01/31	0636	12 54.643	54 10.416	HRP	57	-	HRP onboard
01/31	0731	12 52.5660	54 07.8372	HRP	58	2000	HRP away
01/31	0901	12 52.446	54 07.952	HRP	58	-	HRP onboard
01/31	1003	12 48.3916	54 03.4221	HRP	59	2000	HRP away
01/31	1137	12 48.217	54 03.550	HRP	59	-	HRP onboard
01/31	1259	12 56.8667	54 03.5088	HRP	60	2000	HRP away
01/31	1426	12 56.785	54 03.629	HRP	60	-	HRP onboard
01/31	1527	12 54.6936	54 05.6123	HRP	61	2000	HRP away
01/31	1657	12 54.6601	54 05.8198	HRP	61	-	HRP onboard
01/31	1755	12 50.6474	54 09.9454	HRP	62	2000	HRP away
01/31	1924	12 50.5627	54 10.0750	HRP	62	-	HRP onboard
01/31	2019	12 48.4158	54 12.0562	HRP	63	2000	HRP away
01/31	2150	12 48.2877	54 12.2311	HRP	63	-	HRP onboard
02/01	0104	12 50.6852	54 13.5103	INJ	-	-	I.S. deployed
02/01	1312	12 59.4087	54 12.2910	INJ	-	-	I.S. onboard
02/01	1312	12 59.4087	54 12.2910	HRP	64	2000	HRP away
02/01	1442	12 59.308	54 12.448	HRP	64	-	HRP onboard
02/01	1538	13 02.2467	54 09.4330	HRP	65	2000	HRP away
02/01	1710	13 02.1713	54 09.6342	HRP	65	-	HRP onboard
02/01	1807	12 56.4380	54 15.2982	HRP	66	2000	HRP away
02/01	1940	12 56.3323	54 15.4296	HRP	66	-	HRP onboard
02/01	2048	12 53.7699	54 18.1187	HRP	67	2000	HRP away
02/01	2215	12 53.6721	54 18.2459	HRP	67	-	HRP onboard
02/02	0039	12 52.3674	54 18.8151	INJ	-	-	I.S. deployed
02/02	1231	13 03.8772	54 19.0075	HRP	68	2000	HRP away
02/02	1249	13 04.1660	54 18.9868	INJ	-	-	I.S. recovered
02/02	1357	13 03.783	54 19.180	HRP	68	-	HRP onboard
02/02	1512	13 09.9361	54 15.1885	HRP	69	2000	HRP away
02/02	1643	13 09.8154	54 15.3648	HRP	69	-	HRP onboard
02/02	1749	12 59.9237	54 15.2500	HRP	70	2000	HRP away
02/02	1923	12 59.9237	54 14.9611	HRP	70	-	HRP onboard
02/02	2041	12 50.0177	54 15.0040	HRP	71	2000	HRP away
02/02	2206	12 49.9753	54 15.1297	HRP	71	-	HRP onboard

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02/02	-	- -	- -	INJ	-	-	I.S. deployed
02/03	1226	13 05.6932	54 15.8104	HRP	72	2000	HRP away
02/03	1245	13 05.6895	54 15.8712	INJ	-	-	I.S. recovered
02/03	1352	13 05.559	54 15.928	HRP	72	-	HRP onboard
02/03	1618	13 10.0753	54 35.1129	HRP	73	2000	HRP away
02/03	1756	13 10.1911	54 35.3516	HRP	73	-	HRP onboard
02/03	1917	13 00.0471	54 34.9855	HRP	74	2000	HRP away
02/03	2043	13 00.0340	54 35.1394	HRP	74	-	HRP onboard
02/03	2200	12 50.0012	54 34.9936	HRP	75	2000	HRP away
02/03	2325	12 49.9741	54 35.0695	HRP	75	-	HRP onboard
02/04	0141	12 59.2453	54 32.2828	INJ	-	-	I.S. deployed
02/04	1326	13 12.0855	54 30.9881	HRP	76	2000	HRP away
02/04	1352	13 12.1230	54 30.7269	INJ	-	-	I.S. recovered
02/04	1501	13 11.918	54 31.256	HRP	76	-	HRP onboard
02/04	1611	13 10.0198	54 25.0949	HRP	77	2000	HRP away
02/04	1738	13 09.9650	54 25.2644	HRP	77	-	HRP onboard
02/04	1856	12 59.9588	54 25.0426	HRP	78	2000	HRP away
02/04	2025	12 59.8917	54 25.2204	HRP	78	-	HRP onboard
02/04	2150	12 49.7865	54 25.1828	HRP	79	2000	HRP away
02/04	2315	12 49.7524	54 25.2985	HRP	79	-	HRP onboard
02/05	0118	13 00.3282	54 19.6890	INJ	-	-	I.S. deployed
02/05	1320	13 14.138	54 18.617	INJ	-	-	I.S. recovered
02/05	1308	13 13.933	54 18.755	HRP	80	2000	HRP away
02/05	1440	13 13.755	54 18.859	HRP	80	-	HRP onboard
02/05	1605	13 03.0116	54 18.859	HRP	81	2000	HRP away
02/05	1731	13 02.9878	54 21.1781	HRP	81	-	HRP onboard
02/05	1851	13 02.9473	54 33.1656	HRP	82	2000	HRP away
02/05	2017	13 02.9759	54 33.3654	HRP	82	-	HRP onboard
02/05	2139	13 03.0090	54 45.0012	HRP	83	2000	HRP away
02/05	2306	13 03.0585	54 45.2220	HRP	83	-	HRP onboard
02/05	2336	13 03.4180	54 45.1357	INJ	-	-	I.S. in water
02/06	1220	13 18.2488	54 44.5869	INJ	-	-	I.S. recovered
02/06	1248	13 18.2376	54 44.4781	HRP	84	2000	HRP away
02/06	1419	13 18.183	54 44.562	HRP	84	-	HRP onboard
02/06	1530	13 12.9840	54 38.1187	HRP	85	2000	HRP away
02/06	1535	13 13.000	54 38.120	INJ	-	-	snsr intercal strt
02/06	1640	13 12.877	54 38.572	INJ	-	-	snsr intercal end
02/06	1701	13 12.902	54 38.263	HRP	85	-	HRP onboard
02/06	1809	13 07.9611	54 31.0471	HRP	86	2000	HRP away
02/06	1936	13 07.9558	54 31.2392	HRP	86	-	HRP onboard
02/06	2100	13 03.0242	54 23.9914	HRP	87	2000	HRP away
02/06	2226	13 03.1741	54 23.1561	HRP	87	-	HRP onboard
02/07	0007	13 03.5993	54 23.9247	INJ	-	-	I.S. deployed
02/07	1000	13 13.0653	54 21.6619	-	-	-	**new HRP battery**
02/07	1208	13 15.8325	54 21.6619	HRP	88	2000	HRP away
02/07	1217	13 16.0202	54 21.6214	INJ	-	-	I.S. recovered ** last I.S. **
02/07	1331	13 15.814	54 21.729	HRP	88	-	HRP onboard
02/07	1715	13 00.0	53 54.0	CTD	01	1000	CTD deployed
02/07	1752	13 00.4084	53 54.3325	HRP	89	2000	HRP away
02/07	1921	13 00.3430	53 54.4707	HRP	89	-	HRP onboard
02/08	1310	10 30.0	55 00.0	CTD	25	1000	CTD deployed
02/08	1325	10 30.22	54 59.63	HRP	90	2000	HRP away
02/08	1458	10 30.09	54 59.27	HRP	90	-	HRP onboard

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02/08	1634	10 44.92	54 59.87	HRP	91	2000	HRP away
02/08	1800	10 44.72	54 59.48	HRP	91	-	HRP onboard
02/08	1954	11 00.00	54 59.95	HRP	92	2000	HRP away
02/08	2124	10 59.90	54 59.52	HRP	92	-	HRP onboard
02/08	2312	11 15.08	54 59.96	CTD	26	1000	CTD deployed
02/08	2323	11 15.1814	54 59.6592	HRP	93a	0	aborted mid-dive
02/08	2353	11 15.5435	54 59.4178	CTD	26	-	recover CTD
02/09	0009	11 15.0106	54 58.9094	HRP	93a	-	HRP onboard
02/09	0035	11 14.7562	54 58.0295	CTD	27	1000	CTD deployed
02/09	0044	11 14.7467	54 57.8025	HRP	93	2000	HRP away
02/09	0209	11 14.0609	54 57.2953	HRP	93	-	HRP onboard
02/09	0347	11 30.0623	54 59.9116	HRP	94	2000	HRP away
02/09	0520	11 29.907	54 59.212	HRP	94	-	HRP onboard
02/09	0701	11 44.9348	54 59.9534	HRP	95	2000	HRP away
02/09	0832	11 44.992	54 59.446	HRP	95	-	HRP onboard
02/09	1004	12 00.0413	54 59.9624	HRP	96	2000	HRP away
02/09	1133	12 00.294	54 59.863	HRP	96	-	HRP onboard
02/09	1300	12 15.0	55.0.0	CTD	28	1000	CTD deployed
02/09	1320	12 15.2887	54 59.7819	HRP	97	2000	HRP away
02/09	1446	12 15.367	54 59.869	HRP	97	-	HRP onboard
02/09	1624	12 30.0147	55 00.0606	HRP	98	2000	HRP away
02/09	1809	12 29.9004	55 00.4505	HRP	98	-	HRP onboard
02/09	1950	12 45.0120	54 59.9929	HRP	99	2000	HRP away
02/09	2113	12 45.0900	55 00.1417	HRP	99	-	HRP onboard
02/09	2243	13 00.0895	54 59.9300	HRP	100	2000	HRP away
02/10	0007	13 00.1417	55 00.1524	HRP	100	-	HRP onboard
02/10	0142	13 14.9812	55 00.0775	HRP	101	2000	HRP away
02/10	0306	13 15.0164	55 00.2505	HRP	101	-	HRP onboard
02/10	0446	13 29.9802	55 00.0300	HRP	102	2000	HRP away
02/10	0613	13 29.854	55 00.0802	HRP	102	-	HRP onboard
02/10	0803	13 45.0121	55 00.0144	HRP	103	2000	HRP away
02/10	0927	13 44.991	55 00.250	HRP	103	-	HRP onboard
02/10	1059	14 00.0239	55 00.0125	HRP	104	2000	HRP away
02/10	1223	14 00.142	55 00.138	HRP	104	-	HRP onboard
02/10	1354	14 15.0796	54 59.9658	CTD	29	1000	CTD deployed
02/10	1403	14 15.2043	54 59.9739	HRP	105	2000	HRP away
02/10	1525	14 15.238	55 00.031	HRP	105	-	HRP onboard
02/10	1703	14 30.0325	54 59.9630	HRP	106	2000	HRP away
02/10	1828	14 29.9444	54 59.9225	HRP	106	-	HRP onboard
02/10	2007	14 45.0380	55 00.0228	HRP	107	2000	HRP away
02/10	2145	14 45.0718	54 59.9923	HRP	107	-	HRP onboard
02/10	2320	-	-	CTD	30	1000	CTD deployed
02/10	2330	15 00.2682	54 59.9702	HRP	108	2000	HRP away
02/11	0103	15 00.4843	55 00.0585	HRP	108	-	HRP onboard
02/11	0237	15 15.0580	55 00.1118	HRP	109	2000	HRP away
02/11	0412	15 15.2713	55 00.1602	HRP	109	-	HRP onboard
02/12	1700	- -	- -	-	-	-	return Barbados

Appendix B

SFTRE-2 Cruise Log

SJ0112

Barbados -> San Juan

October 29 - December 4, 2001

Date mo/da	time GMT	position Latitude(N)	Longitude(W)	what	dive# (btl#)	pmax	comments
10/29	2100	13 06.119	59 03.90	-	-	-	Scientists aboard
10/29	2100	- -	- -	-	-	-	Dep. Bridgetown
10/30	????	12 34.000	59 40.0	CTD	1	1000	First CTD
10/30	????	12 04.000	59 42.4	CTD	2	1000	
10/30	????	11 34.000	59 44.0	CTD	3	1000	
10/30	1600	11 54.713	59 23.847	CTD	4	1000	
10/30	1631	11 54.906	59 23.664	HRP	1	926	HRP deployed
10/30	1754	11 55.036	59 23.798	HRP	1	926	HRP recovered
10/30	2043	11 51.072	58 54.966	CTD	5	1000	
10/30	2112	11 51.602	58 54.918	HRP	2	1250	HRP deployed
10/30	2200	11 51.997	58 55.025	HRP	2	1250	HRP recovered
10/31	0128	11 47.991	58 25.044	CTD	6	1000	
10/31	0203	11 47.971	58 24.779	HRP	3	1250	HRP deployed
10/31	0300	11 47.981	58 24.767	HRP	3	1250	HRP recovered
10/31	0620	11 44.230	57 52.130	CTD	7	1000	
10/31	0651	11 44.928	57 52.261	HRP	4	2000	HRP deployed
10/31	0817	11 44.944	57 52.330	HRP	4	2000	HRP recovered
10/31	1200	11 41.5	57 18.9	CTD	8	1000	
10/31	1201	11 41.52	57 18.93	HRP	5	1947	HRP deployed
10/31	1333	11 41.52	57 18.926	HRP	5	1947	HRP recovered
10/31	1638	11 38.134	56 45.994	CTD	9	1000	
10/31	1659	11 38.421	56 45.888	HRP	6	2000	HRP deployed
10/31	1821	11 38.438	56 45.928	HRP	6	2000	HRP recovered
10/31	2149	11 34.969	56 13.074	CTD	10	1000	
10/31	2200	11 35.077	56 13.153	HRP	7	2000	HRP deployed
10/31	2332	11 35.318	56 13.245	HRP	7	2000	HRP recovered
11/01	0248	11 31.5	55 40.0	CTD	11	1000	
11/01	0250	11 31.625	55 39.890	HRP	8	2000	HRP deployed
11/01	0424	11 31.522	55 39.927	HRP	8	2000	HRP recovered
11/01	0740	11 28.3	55 7.1	CTD	12	1000	
11/01	0743	11 28.827	55 7.095	HRP	9	2000	HRP deployed
11/01	0918	11 28.156	55 7.094	HRP	9	2000	HRP recovered
11/01	1237	11 25.031	54 34.014	CTD	13	1000	
11/01	1237	11 25.031	54 34.014	HRP	10	2000	HRP deployed
11/01	1410	11 31.522	54 39.927	HRP	10	2000	HRP recovered
11/01	1727	11 21.692	54 0.978	CTD	14	1000	
11/01	1727	11 21.692	54 0.978	HRP	11	2000	HRP deployed
11/01	1857	11 21.705	54 0.943	HRP	11	2000	HRP recovered
11/01	2212	10 52.191	54 17.993	CTD	15	1000	
11/01	2212	10 52.191	54 17.993	HRP	12	2000	HRP deployed
11/01	2347	10.52.327	54 18.37	HRP	12	2000	HRP recovered
11/02	0311	10 24.957	54 37.045	CTD	16	1000	
11/02	0311	10 24.957	54 37.045	HRP	13	2000	HRP deployed
11/02	0430	- -	- -	-	-	-	(HRP hit by *RVSJ*
11/02	0430	- -	- -	-	-	-	on recovery)
11/02	0451	10 24.862	54 37.465	HRP	13	2000	HRP recovered
11/02	0815	10 28.17	55 9.2	CTD	17	1000	

Date mo/da	time GMT	position Latitude(N)	Longitude(W)	what	dive# (btl#)	pmax	comments
11/02	1230	10 31.59	55 42.99	CTD	18	2000	
11/02	1700	10 34.9	56 16.0	CTD	19	2000	
11/02	2130	11 15.0	56 37.0	CTD	20	1000	
11/02	2145	- -	- -	-	-	-	* HRP repaired *
11/02	2204	11 15.308	56 37.034	HRP	14	1000	HRP deployed
11/02	2314	11 14.556	54 38.212	HRP	14	1000	HRP recovered
11/03	0209	11 02.069	57 08.886	CTD	21	1000	
11/03	0209	11 02.069	57 08.886	HRP	15	2000	HRP deployed
11/03	0431	11 02.434	57 08.874	HRP	15	2000	HRP recovered
11/03	0655	10 49.01	57 41.12	CTD	22	1000	
11/03	0656	10 49.007	57 41.1165	HRP	16	2000	HRP deployed
11/03	0833	10 49.0287	57 41.4270	HRP	16	2000	HRP recovered
11/03	1140	10 53.48	58 15.05	CTD	23	1000	
11/03	1140	10 53.512	58 15.006	HRP	17	2000	HRP deployed
11/03	1309	10 53.206	58 15.204	HRP	17	2000	HRP recovered
11/03	1616	10 59.96	58 48.15	CTD	24	1000	
11/03	1630	10 59.886	58 48.180	HRP	18	1600	HRP deployed
11/03	1750	10 59.199	58 48.173	HRP	18	1600	HRP recovered
11/03	2102	11 04.021	59 23.990	CTD	25	1000	
11/03	2120	11 04.274	59 24.074	HRP	19	1600	HRP deployed
11/03	2234	11 04.392	59 23.949	HRP	19	1600	HRP recovered
11/04	0100	11 12.24	59 51.93	CTD	26	1000	
11/04	0130	11 12.239	59 51.924	HRP	20	1475	HRP deployed
11/04	0241	11 12.751	59 51.789	HRP	20	1475	HRP recovered
11/04	0540	11 34.99	60 15.01	CTD	27	1000	
11/04	0640	11 35.0267	60 15.0038	HRP	21	1343	HRP deployed
11/04	0718	11 35.1361	60 14.7577	HRP	21	1343	HRP recovered
11/04	1032	11 36.77	60 49.03	CTD	28	0700	
11/04	1113	11 36.7702	60 49.0385	HRP	22	0780	HRP deployed
11/04	1125	11 36.6397	60 48.8473	HRP	22	0780	HRP recovered
11/04	1438	11 47.92	61 20.97	CTD	29	1000	
11/04	1440	11 47.9305	61 20.9624	HRP	23	1140	HRP deployed
11/04	1544	11 47.7535	61 21.3270	HRP	23	1140	HRP recovered
11/04	1929	12 05.029	60 48.00	CTD	30	1000	
11/04	1929	12 05.029	60 48.00	HRP	24	2000	HRP deployed
11/04	2112	12 04.730	60 48.309	HRP	24	2000	HRP recovered
11/05	0040	12 22.113	60 15.983	CTD	31	1000	
11/05	0040	12 22.113	60 15.983	HRP	25	2000	HRP deployed
11/05	0212	12 22.511	60 16.327	HRP	25	2000	HRP recovered
11/05	0511	12 55.10	60 19.98	CTD	32	1000	
11/05	0510	12 55.0706	60 19.9632	HRP	26	2000	HRP deployed
11/05	0642	12 55.1371	60 20.3624	HRP	26	2000	HRP recovered
11/05	0934	13 08.99	59 56.15	CTD	33	1000	
11/05	0932	13 08.9715	59 56.1402	HRP	27	1700	HRP deployed
11/05	1050	13 09.0258	59 56.2947	HRP	27	1700	HRP recovered
11/05	1130	13 06.119	59 03.90	-	-	-	arrive Barbados
11/05	1600	13 06.119	59 03.90	-	-	-	depart Barbados
11/05	2114	12 57.817	59 10.067	CTD	34	1000	
11/05	2114	12 57.817	59 10.067	HRP	28	2000	HRP deployed
11/05	2312	12 57.504	59 09.872	HRP	28	2000	HRP recovered
11/06	0223	12 54.507	58 37.018	CTD	35	1000	
11/06	0223	12 54.507	58 37.018	HRP	29	2000	HRP deployed
11/06	0401	12 54.548	58 36.698	HRP	29	2000	HRP recovered
11/06	0718	12 51.28	58 03.93	CTD	36	1000	

Date mo/da	time GMT	position Latitude(N)	Longitude(W)	what	dive# (btl#)	pmax	comments
11/06	0728	12 51.2882	58 03.9163	HRP	30	2000	HRP deployed
11/06	0951	12 51.2951	58 03.9496	HRP	30	2000	HRP recovered
11/06	1228	12 47.86	57 30.97	CTD	37	1000	
11/06	1227	12 47.8712	57 30.9760	HRP	31	2000	HRP deployed
11/06	1405	12 48.1227	57 30.9627	HRP	31	2000	HRP recovered
11/06	1715	12 44.735	56 57.998	CTD	38	1000	
11/06	1716	12 44.735	56 57.998	HRP	32	2000	HRP deployed
11/06	1848	12 44.830	56 57.835	HRP	32	2000	HRP recovered
11/06	2200	12 41.312	56 25.044	CTD	39	1000	
11/06	2200	12 41.312	56 25.044	HRP	33	2000	HRP deployed
11/06	2333	12 41.138	56 24.712	HRP	33	2000	HRP recovered
11/07	0240	12 38.0	55 52.0	CTD	40	1000	
11/07	0240	12 38.0196	55 51.978	HRP	34	2000	HRP deployed
11/07	0419	12 37.9066	55 51.2652	HRP	34	2000	HRP recovered
11/07	0735	12 34.80	55 19.01	CTD	41	1000	
11/07	0737	12 34.7967	55 19.0076	HRP	35	2000	HRP deployed
11/07	0910	12 34.5979	55 18.7287	HRP	35	2000	HRP recovered
11/07	1230	12 31.51	54 45.91	CTD	42	1000	
11/07	1232	12 31.5123	54 45.9071	HRP	36	2000	HRP deployed
11/07	1404	12 31.6279	54 45.8155	HRP	36	2000	HRP recovered
11/07	1500	- -	- -	-	-	-	**new HRP battery**
11/07	1742	12 28.1345	54 13.0299	CTD	43	1000	
11/07	1742	12 28.1345	54 13.0299	HRP	37	2000	HRP deployed
11/07	1930	12 28.1345	54 13.3008	HRP	37	2000	HRP recovered
11/07	2245	12 24.7069	53 39.9619	CTD	44	1000	
11/07	2245	12 24.7069	53 39.9619	HRP	38	2000	HRP deployed
11/08	0020	12 24.942	53 39.881	HRP	38	2000	HRP recovered
11/08	0337	12 21.517	53 07.009	CTD	45	1000	
11/08	0400	12 21.52	53 07.0	-	-	-	GC melted down
11/08	0337	12 21.517	53 07.0098	HRP	39	2000	HRP deployed (TS1)
11/08	0510	12 21.5242	53 06.8783	HRP	39	2000	HRP recovered
	since GC is out of commission, do a HRP time series here until fixed						
11/08	0641	12 21.5314	53 07.0238	HRP	40	2000	HRP deployed(TS2)
11/08	0815	12 21.6055	53 06.8604	HRP	40	2000	HRP recovered
11/08	0942	12 21.4894	53 07.0059	HRP	41	2000	HRP deployed(TS3)
11/08	1118	12 21.4468	53 06.8365	HRP	41	2000	HRP recovered
11/08	1246	12 21.4815	53 07.1734	HRP	42	2000	HRP deployed(TS4)
11/08	1441	12 21.4168	53 07.0232	HRP	42	2000	HRP recovered
11/08	1542	12 21.5204	53 07.2636	HRP	43	2000	HRP deployed(TS5)
11/08	1711	12 21.551	53 07.128	HRP	43	2000	HRP recovered
	GC repaired, and there is tracer in the last sample, so eastward we go						
11/08	2033	12 18.3552	52 33.7460	CTD	46	1000	
11/08	2033	12 18.3552	52 33.7460	HRP	44	2000	HRP deployed
11/08	2209	12 18.329	52 33.427	HRP	44	2000	HRP recovered
11/09	0109	12 14.957	52 0.995	CTD	47	1000	
11/09	0109	12 14.957	52 0.995	HRP	45	2000	HRP deployed
11/09	0238	12 15.188	52 0.828	HRP	45	2000	HRP recovered
11/09	0551	12 46.53	51 54.27	CTD	48	1000	
11/09	0552	12 46.5279	51 54.2703	HRP	46	2000	HRP deployed
11/09	0726	12 46.6177	51 54.0404	HRP	46	2000	HRP recovered
11/09	1028	13 18.15	51 47.35	CTD	49	1000	
11/09	1030	13 18.1448	51 47.3740	HRP	47	2000	HRP deployed
11/09	1155	13 18.1759	51 47.4208	HRP	47	2000	HRP recovered
11/09	1454	13 21.4888	52 20.6533	CTD	50	1000	

Date mo/da	time GMT	position Latitude(N)	Longitude(W)	what	dive# (btl#)	pmax	comments
11/09	1454	13 21.4768	52 20.6480	HRP	48	2000	HRP deployed
11/09	1620	13 21.495	52 20.658	HRP	48	2000	HRP recovered
11/09	1917	13 24.7341	52 53.6106	CTD	51	1000	
11/09	1917	13 24.7341	52 53.6106	HRP	49	1500	HRP deployed
11/09	2027	13 24.696	52 53.668	HRP	49	1500	HRP recovered
11/09	2342	13 28.2584	53 30.3981	CTD	52	1000	
11/09	2342	13 28.2584	53 30.3981	HRP	50	1500	HRP deployed
11/10	0056	13 28.118	53 30.347	HRP	50	1500	HRP recovered
11/10	0412	13 32.142	54 07.252	HRP	51	1500	HRP deployed
11/10	0414	13 32.14	54 07.28	CTD	53	1000	
11/10	0532	13 32.0716	54 07.5214	HRP	51	1500	HRP recovered
11/10	0843	13 35.6393	54 44.0041	HRP	52	1500	HRP deployed
11/10	0846	13 35.62	54 43.98	CTD	54	1000	
11/10	1002	13 35.7089	54 44.3679	HRP	52	1500	HRP recovered
11/10	1324	13 39.4870	55 20.8096	CTD	55	1000	
11/10	1324	13 39.4870	55 20.8096	HRP	53	1500	HRP deployed
11/10	1432	13 39.5848	55 21.0304	HRP	53	1500	HRP recovered
11/10	1747	13 43.1518	55 57.6229	CTD	56	1000	
11/10	1747	13 43.1518	55 57.6229	HRP	54	1500	HRP deployed
11/10	1854	13 43.380	55 57.901	HRP	54	1500	HRP recovered
11/10	2213	13 46.8091	56 34.4459	CTD	57	1000	
11/10	2213	13 46.8091	56 34.4459	HRP	55	1500	HRP deployed
11/10	2319	13 46.7377	56 34.4720	HRP	55	1500	HRP recovered
11/11	0241	13 50.5470	57 11.1840	CTD	58	1000	
11/11	0241	13 50.5470	57 11.1840	HRP	56	1500	HRP deployed
11/11	0351	13 50,5403	57 11.1453	HRP	56	1500	HRP recovered
11/11	0712	13 54.1619	57 48.0132	CTD	59	1000	
11/11	0712	13 54.1619	57 48.0132	HRP	57	1500	HRP deployed
11/11	0818	13 54.1154	57 48.0086	HRP	57	1500	HRP recovered
11/11	1138	13 57.9330	58 24.7756	CTD	60	1000	
11/11	1138	13 57.9330	58 24.7756	HRP	58	1500	HRP deployed
11/11	1255	13 57.6447	58 25.0248	HRP	58	1500	HRP recovered
11/11	1613	14 01.5734	59 01.5422	CTD	61	1000	
11/11	1613	14 01.5734	59 01.5422	HRP	59	2451	HRP deployed
11/11	1805	14 01.4628	59 01.9967	HRP	59	2451	HRP recovered
11/11	2125	14 11.0041	59 38.4426	CTD	62	1000	
11/11	2125	14 11.0041	59 38.4426	HRP	60	2485	HRP deployed
11/11	2331	14 11.2912	59 38.7616	HRP	60	2485	HRP recovered
11/12	0248	14 15.0127	60 15.0650	CTD	63	1000	
11/12	0248	14 15.0127	60 15.0650	HRP	61	1524	HRP deployed
11/12	0431	14 15.0319	60 15.3823	HRP	61	1524	HRP recovered
11/12	0749	14 47.9267	60 15.0712	CTD	64	1000	
11/12	0749	14 47.9267	60 15.0712	HRP	62	2478	HRP deployed
11/12	0945	14 48.0981	60 15.5709	HRP	62	2478	HRP recovered
11/12	1313	15 21.0796	60 14.9403	CTD	65	1000	
11/12	1313	15 21.0796	60 14.9403	HRP	63	1500	HRP deployed
11/12	1434	15 20.7747	60 14.8486	HRP	63	1500	HRP recovered
11/12	1750	15 13.0176	59 42.0317	CTD	66	1000	
11/12	1750	15 13.0176	59 42.0317	HRP	64	1500	HRP deployed
11/12	1909	15 13.0332	59 41.6643	HRP	64	1500	HRP recovered
11/12	2230	15 03.9823	59 08.9297	CTD	67	1000	
11/12	2230	15 03.9823	59 08.9297	HRP	65	1500	HRP deployed
11/12	2342	15 04.1720	59 08.5396	HRP	65	1500	HRP recovered
11/13	0309	15 00.3072	58 32.1921	CTD	68	1000	

Date mo/da	time GMT	position Latitude(N)	Longitude(W)	what	dive# (btl#)	pmax	comments
11/13	0309	15 00.3072	58 32.1921	HRP	66	1500	HRP deployed
	The CTD winch broke during CTD 68 - the CTD was stuck at 900 m						
	The HRP was recovered around the CTD, then the CTD was recovered						
11/13	0426	15 00.2282	58 31.9447	HRP	66	1500	HRP recovered
11/13	1307	15 00.32	58 33.30	CTD	69	1000	redo of 68
11/13	1400ish	The ship's time server was mysteriously set to Dec. 13 for					
		~2 hours today. This affects all shipboard data logging					
11/13	1755	14 56.6239	57 55.4354	CTD	70	1000	
11/13	1755	14 56.6239	57 55.4354	HRP	67	1500	HRP deployed
11/13	1911	14 56.6239	57 55.4354	HRP	67	1500	HRP recovered
11/13	2245	14 53.0408	57 18.6366	CTD	71	1000	
11/13	2245	14 53.0408	57 18.6366	HRP	68	1500	HRP deployed
11/13	2355	14 53.2025	57 18.9703	HRP	68	1500	HRP recovered
11/14	0327	14 49.3582	56 41.7662	CTD	72	1000	
11/14	0327	14 49.3582	56 41.7622	HRP	69	1500	HRP deployed
11/14	0543	14 49.4426	56 41.6692	HRP	69	1500	HRP recovered
11/14	0913	14 45.5608	56 05.4110	CTD	73	1000	
11/14	0913	14 45.5608	56 05.4110	HRP	70	1500	HRP deployed
11/14	1021	14 45.7278	56 05.6146	HRP	70	1500	HRP recovered
11/14	1355	14 41.93	55 28.24	CTD	74	1000	
11/14	1356	14 41.9313	55 28.2364	HRP	71	1500	HRP deployed
11/14	1509	14 41.9623	55 28.3261	HRP	71	1500	HRP recovered
11/14	1835	14 38.125	54 51.427	CTD	75	1000	
11/14	1835	14 38.125	54 51.427	HRP	72	1500	HRP deployed
11/14	1950	14 38.0903	54 51.6218	HRP	72	1500	HRP recovered
11/14	2326	14 34.5938	54 14.7193	CTD	76	1000	
11/14	2326	14 34.5938	54 14.7193	HRP	73	1500	HRP deployed
11/15	0037	14 34.4947	54 15.0291	HRP	73	1500	HRP recovered
11/15	0415	14 30.8872	53 37.8351	CTD	77	1000	
11/15	0415	14 30.8872	53 37.8351	HRP	74	1500	HRP deployed
11/15	0529	14 30.6698	53 37.9435	HRP	74	1500	HRP recovered
11/15	0904	14 27.2788	53 00.9577	CTD	78	1000	
11/15	0904	14 27.2788	53 00.9577	HRP	75	1500	HRP deployed
11/15	1018	14 27.3722	53 01.2537	HRP	75	1500	HRP recovered
11/15	1355	13 51.2304	53 00.9381	CTD	79	1000	
11/15	1355	13 51.2304	53 00.9381	HRP	76	1500	HRP deployed
11/15	1355	- -	- -	-	-	-	**** 1000th HRP ****
11/15	1504	13 51.2073	53 01.384	HRP	76	1500	HRP recovered
11/15	1835	13 15.2182	53 00.9571	CTD	80	1000	
11/15	1835	13 15.2182	53 00.9571	HRP	77	1500	HRP deployed
11/15	1952	13 15.1903	53 00.8126	HRP	77	1500	HRP recovered
11/15	2238	12 39.1113	53 00.9640	CTD	81	1000	
11/15	2238	12 39.1113	53 00.9640	HRP	78	1500	HRP deployed
11/16	0042	12 39.0049	53 00.6039	HRP	78	1500	HRP recovered
11/16	0412	12 03.21	53 01.03	CTD	82	1000	
11/16	0412	12 03.2146	53 01.0214	HRP	79	1500	HRP deployed
11/16	0524	12 03.0650	53 00.8913	HRP	79	1500	HRP recovered
11/16	0942	11 27.3443	53 00.8318	CTD	83	1000	
11/16	0942	11 27.3443	53 00.8318	HRP	80	1500	HRP deployed
11/16	1014	11 27.4135	53 00.9012	HRP	80	1500	HRP recovered
11/16	1408	10 51.2739	53 00.9619	CTD	84	1000	
11/16	1408	10 51.2739	53 00.9619	HRP	81	1500	HRP deployed
11/16	1524	10 51.4315	53 00.7796	HRP	81	1500	HRP recovered
11/16	1907	10 47.5397	52 24.2499	CTD	85	1000	

Date mo/da	time GMT	position Latitude(N)	Longitude(W)	what	dive# (btl#)	pmax	comments
11/16	1907	10 47.5397	52 24.2499	HRP	82	1500	HRP deployed
11/16	2023	10 47.5824	52 24.1408	HRP	82	1500	HRP recovered
11/16	2350	11 09.0898	51 55.9904	CTD	86	1000	
11/16	2358	11 09.1298	51 55.9616	HRP	83	1500	HRP deployed
11/17	0105	11 09.2431	51 55.9653	HRP	83	1500	HRP recovered
11/17	0448	11 5.43	51 19.34	CTD	87	1000	
11/17	0448	- -	- -	-	-	-	no HRP - bad radio
11/17	0930	11 01.7379	50 42.3483	CTD	88	1000	
11/17	0930	11 01.7379	50 42.3483	HRP	84	1500	HRP deployed
11/17	1044	11 01.7506	50 42.3915	HRP	84	1500	HRP recovered
11/17	1429	10 57.9464	50 05.6189	CTD	89	1000	
11/17	1429	10 57.9464	50 05.6189	HRP	85	1500	HRP deployed
11/17	1540	10 57.6144	50 05.5030	HRP	85	1500	HRP recovered
11/17	1800	- -	- -	-	-	-	**new HRP battery**
11/17	1947	10 54.3358	49 28.8382	CTD	90	1000	
11/17	1951	10 54.3622	49 28.8754	HRP	86	1500	HRP deployed
11/17	2105	10 54.5561	49 28.6507	HRP	86	1500	HRP recovered
11/18	0050	10 50.6	48 52.0	CTD	91	800	
11/18	0054	10 50.5938	48 52.0453	HRP	87	1500	HRP deployed
11/18	0206	10 50.6486	48 52.0944	HRP	87	1500	HRP recovered
11/18	0547	10 46.9	48 15.2	CTD	92	1000	
11/18	0547	10 46.9661	48 15.1578	HRP	88	1500	HRP deployed
11/18	0700	10 46.9761	48 14.9744	HRP	88	1500	HRP recovered
11/18	1003	11 18.60	48 08.46	CTD	93	1000	
11/18	1004	11 18.6584	48 08.5047	HRP	89	1500	HRP deployed
11/18	1127	11 18.7705	48 08.5526	HRP	89	1500	HRP recovered
11/18	1428	11 50.13	48 01.80	CTD	94	1000	
11/18	1429	11 50.1511	48 01.8188	HRP	90	1500	HRP deployed
11/18	1533	11 50.1449	48 01.8314	HRP	90	1500	HRP recovered
11/18	1859	11 53.8502	48 38.6229	CTD	95	1000	
11/18	1859	11 53.8502	48 38.6229	HRP	91	1500	HRP deployed
11/18	2009	11 53.9596	48 38.6791	HRP	91	1500	HRP recovered
11/18	2333	11 57.5628	49 15.3502	CTD	96	1000	
11/18	2333	11 57.5628	49 15.3502	HRP	92	1500	HRP deployed
11/19	0041	11 57.7277	49 15.4749	HRP	92	1500	HRP recovered
11/19	0402	12 01.1895	49 52.1768	CTD	97	1000	
11/19	0402	12 01.1895	49 52.1768	HRP	93	1500	HRP deployed
11/19	0515	12 01.1495	49 52.2849	HRP	93	1500	HRP recovered
11/19	0838	12 04.9254	50 29.0720	CTD	98	1000	
11/19	0838	12 04.0004	50 29.1371	HRP	94	1500	HRP deployed
11/19	0959	12 04.8456	50 29.1265	HRP	94	1500	HRP recovered
11/19	1318	12 08.5454	51 05.8148	CTD	99	1000	
11/19	1318	12 08.5454	51 05.8148	HRP	95	1500	HRP deployed
11/19	1425	12 08.3614	51 05.7461	HRP	95	1500	HRP recovered
11/19	1730	12 40.5775	50 58.9938	CTD	100	1000	
11/19	1730	12 40.5775	50 58.9938	HRP	96	1500	HRP deployed
11/19	1840	12 40.5071	50 58.8545	HRP	96	1500	HRP recovered
11/19	2136	13 12.4766	50 51.9659	CTD	101	1000	
11/19	2136	13 12.4766	50 51.9659	HRP	97	1500	HRP deployed
11/19	2244	13 12.5197	50 52.0110	HRP	97	1500	HRP recovered
11/20	0213	13 08.8110	50 15.1470	CTD	102	1000	
11/20	0213	13 08.8110	50 15.1470	HRP	98	1500	HRP deployed
11/20	0324	13 08.9911	50 15.2659	HRP	98	1500	HRP recovered
11/20	0650	13 05.1080	49 38.4173	CTD	103	1000	

Date mo/da	time GMT	position Latitude(N)	Longitude(W)	what	dive# (btl#)	pmax	comments
11/20	0650	13 05.1080	49 38.4173	HRP	99	1500	HRP deployed
11/20	0808	13 04.9909	49 38.6052	HRP	99	1500	HRP recovered
11/20	1144	13 01.5529	49 01.4844	CTD	104	1000	
11/20	1144	13 01.5529	49 01.4844	HRP	100	1500	HRP deployed
11/20	1259	13 01.7506	49 01.6429	HRP	100	1500	HRP recovered
11/20	1630	12 57.7976	48 24.7730	CTD	105	1000	
11/20	1630	12 57.7976	48 24.7730	HRP	101	1500	HRP deployed
11/20	1741	12 57.8874	48 24.8829	HRP	101	1500	HRP recovered
11/20	2109	12 54.1315	47 47.9860	CTD	106	1000	
11/20	2109	12 54.1315	47 47.9860	HRP	102	1500	HRP deployed
11/20	2219	12 54.1286	47 48.0205	HRP	102	1500	HRP recovered
11/21	0133	13 27.6390	48 01.4169	CTD	107	1000	
11/21	0133	13 27.6390	48 01.4169	HRP	103	1500	HRP deployed
11/21	0245	13 27.6111	48 01.4525	HRP	103	1500	HRP recovered
11/21	0559	14 01.1041	48 14.8095	CTD	108	1000	
11/21	0559	14 01.1041	48 14.8095	HRP	104	1500	HRP deployed
11/21	0708	14 00.9506	48 14.6902	HRP	104	1500	HRP recovered
11/21	1028	14 04.4652	48 51.5384	CTD	109	1000	
11/21	1028	14 04.4652	48 51.5384	HRP	105	1500	HRP deployed
11/21	1138	14 04.4645	48 51.4540	HRP	105	1500	HRP recovered
11/21	1453	14 07.2424	49 28.4222	CTD	110	1000	
11/21	1453	14 07.2424	49 28.4222	HRP	106	1500	HRP deployed
11/21	1600	14 07.3086	49 28.4101	HRP	106	1500	HRP recovered
11/21	1908	14 10.9084	50 05.2687	CTD	111	1000	
11/21	1908	14 10.9084	50 05.2687	HRP	107	1500	HRP deployed
11/21	2015	14 10.9123	50 05.1749	HRP	107	1500	HRP recovered
11/21	2328	14 14.1361	50 41.9830	CTD	112	1000	
11/21	2328	14 14.1361	50 41.9830	HRP	108	1500	HRP deployed
11/22	0040	14 14.2419	50 42.0732	HRP	108	1500	HRP recovered
11/22	0351	14 17.3958	51 18.8327	CTD	113	1000	
11/22	0351	14 17.3958	51 18.8327	HRP	109	1500	HRP deployed
11/22	0520	14 17.3990	51 19.0453	HRP	109	1500	HRP recovered
11/22	0902	14 21.3164	52 00.9727	CTD	114	1000	
11/22	0902	14 21.3164	52 00.9727	HRP	110	1500	HRP deployed
11/22	1110	14 21.4512	52 01.1457	HRP	110	1500	HRP recovered
11/22	1315	navigation logging restarted					
11/22	1320	14 50.6988	51 46.4765	CTD	115	1000	
11/22	1320	14 50.6988	51 46.4765	HRP	111	1500	HRP deployed
11/22	1430	14 50.6534	51 46.5407	HRP	111	1500	HRP recovered
11/22	1740	15 20.1	51 32.0	CTD	116	1000	
11/22	1745	15 20.1894	51 31.9880	HRP	112	5050	HRP deployed
11/22	2115	15 20.2603	51 32.2567	HRP	112	5050	HRP recovered
11/22	2359	15 23.0621	52 02.2498	CTD	117	1000	
11/22	2359	15 23.0621	52 02.2498	HRP	113	1500	HRP deployed
11/23	0108	15 23.1672	52 02.2803	HRP	113	1500	HRP recovered
11/23	0352	15 25.9631	52 32.5444	CTD	118	1000	
11/23	0352	15 25.9631	52 32.5444	HRP	114	5121	HRP deployed
11/23	0725	15 26.1223	52 32.6018	HRP	114	5121	HRP recovered
11/23	1101	15 29.9849	53 13.0259	CTD	119	1000	
11/23	1101	15 29.9849	53 13.0259	HRP	115	1500	HRP deployed
11/23	1210	15 30.0934	53 13.0253	HRP	115	1500	HRP recovered
11/23	1542	15 33.9425	53 53.5110	CTD	120	1000	
11/23	1542	15 33.9425	53 53.5110	HRP	116	1500	HRP deployed
11/23	1648	15 33.8713	53 53.4849	HRP	116	1500	HRP recovered

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11/23	2103	15 37.9887	54 33.9989	CTD	121	1000	
11/23	2103	15 37.9887	54 33.9989	HRP	117	1500	HRP deployed
11/23	2217	15 37.9730	54 33.7806	HRP	117	1500	HRP recovered
11/24	0148	15 42.1932	55 14.5087	CTD	122	1000	
11/24	0148	15 42.1932	55 14.5087	HRP	118	1500	HRP deployed
11/24	0257	15 42.0771	55 14.3400	HRP	118	1500	HRP recovered
11/24	0630	15 46.0036	55 55.0600	CTD	123	1000	
11/24	0630	15 46.0036	55 55.0600	HRP	119	1553	HRP deployed
11/24	1015	15 46.0138	55 54.9149	HRP	119	1553	HRP recovered
11/24	1319	15 51.5823	56 28.9983	CTD	124	1000	
11/24	1322	15 51.5823	56 28.9983	HRP	120	1500	HRP deployed
11/24	1432	15 51.4418	56 28.8888	HRP	120	1500	HRP recovered
11/24	1733	15 56.9432	57 03.0532	CTD	125	1000	
11/24	1733	15 56.9432	57 03.0532	HRP	121	1500	HRP deployed
11/24	1842	15 56.9146	57 03.0456	HRP	121	1500	HRP recovered
11/24	2144	16 00.6278	57 37.0490	CTD	126	1000	
11/24	2144	16 00.6278	57 37.0490	HRP	122	1500	HRP deployed
11/24	2254	16 00.4825	57 36.9530	HRP	122	1500	HRP recovered
11/25	0154	16 04.2210	58 11.0444	CTD	127	1000	
11/25	0154	16 04.2210	58 11.0444	HRP	123	1500	HRP deployed
11/25	0303	16 04.3767	58 11.1113	HRP	123	1500	HRP recovered
11/25	0543	16 07.9733	58 42.0005	CTD	128	1000	
11/25	0544	16 07.9733	58 42.0005	HRP	124	1500	HRP deployed
11/25	0702	16 08.5061	58 42.3035	HRP	124	1500	HRP recovered
11/25	0942	16 11.0634	59 12.0290	CTD	129	1000	
11/25	0942	16 11.0634	59 12.0290	HRP	125	1500	HRP deployed
11/25	1049	16 11.2688	59 12.2431	HRP	125	1500	HRP recovered
11/25	1230	- -	- -	-	-	-	**new HRP battery**
11/25	1431	16 14.9838	59 50.0480	CTD	130	1000	
11/25	1431	16 14.9838	59 50.0480	HRP	126	5015	HRP deployed
11/25	1750	16 14.5356	59 50.0404	HRP	126	5015	HRP recovered
11/25	2154	16 19.9638	60 35.0127	CTD	131	1000	
11/25	2154	16 19.9638	60 35.0127	HRP	127	3309	HRP deployed
11/26	0005	16 19.9638	60 35.0127	HRP	127	3309	HRP recovered
11/26	0324	16 35.0090	61 08.0929	CTD	132	1000	
11/26	0324	16 35.0090	61 08.0929	HRP	128	1500	HRP deployed
11/26	0458	16 34.9699	61 08.3617	HRP	128	1500	HRP recovered
11/26	0808	16 40.00	61 43.61	CTD	133	600	
11/26	0825	16 40.0925	61 43.8850	HRP	129	595	HRP deployed
11/26	0901	16 40.1383	61 44.1540	HRP	129	595	HRP recovered
11/26	1208	16 25.28	62 18.10	CTD	134	1000	
11/26	1213	16 25.2598	62 18.1568	HRP	130	1129	HRP deployed
11/26	1311	16 25.1505	62 18.3327	HRP	130	1129	HRP recovered
11/26	1702	15 42.0160	62 17.9910	CTD	135	1000	
11/26	1702	15 42.0160	62 17.9910	HRP	131	1500	HRP deployed
11/26	1813	15 42.1333	62 18.0047	HRP	131	1500	HRP recovered
11/26	2151	15 02.0080	62 17.1520	CTD	136	1000	
11/26	2151	15 02.0080	62 17.1520	HRP	132	1500	HRP deployed
11/26	2259	15 02.0876	62 17.0408	HRP	132	1500	HRP recovered
11/27	0258	14 18.9989	62 13.0511	CTD	137	1000	
11/27	0258	14 18.9989	62 13.0511	HRP	133	1500	HRP deployed
11/27	0406	14 19.0394	62 13.0501	HRP	133	1500	HRP recovered
11/27	1110	12 57.5300	62 35.0238	CTD	138	1000	
11/27	1110	12 57.5300	62 35.0238	HRP	134	1500	HRP deployed

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11/27	1425	12 57.5247	62 35.0499	HRP	134	1500	HRP recovered
11/27	1532	12 25.0416	62 53.0527	CTD	139	1000	
11/27	1532	12 25.0416	62 53.0527	HRP	135	1500	HRP deployed
11/27	1640	12 25.0675	62 53.1380	HRP	135	1500	HRP recovered
11/27	1948	12 36.03	63 28.15	CTD	140	1000	
11/27	2004	12 36.0273	63 28.3636	HRP	136	1040	HRP deployed
11/27	2054	12 36.2579	63 28.6484	HRP	136	1040	HRP recovered
11/28	0026	13 15.0322	63 28.0301	CTD	141	1000	
11/28	0036	13 14.9863	63 28.1704	HRP	137	1250	HRP deployed
11/28	0137	13 15.1059	63 28.1386	HRP	137	1250	HRP recovered
11/28	0508	13 54.0748	63 36.0381	CTD	142	1000	
11/28	0508	13 54.0748	63 36.0381	HRP	138	1404	HRP deployed
11/28	0615	13 54.2257	63 35.9244	HRP	138	1404	HRP recovered
11/28	0949	14 33.9869	63 41.0926	CTD	143	1000	
11/28	0949	14 33.9869	63 41.0926	HRP	139	1386	HRP deployed
11/28	1059	14 34.3053	63 41.2269	HRP	139	1386	HRP recovered
11/28	1433	15 12.9715	63 37.0337	CTD	144	1000	
11/28	1433	15 12.9715	63 37.0337	HRP	140	1154	HRP deployed
11/28	1533	15 13.1159	63 37.0423	HRP	140	1154	HRP recovered
11/28	1918	15 52.9917	63 37.0206	CTD	145	1000	
11/28	1918	15 52.9917	63 37.0206	HRP	141	1500	HRP deployed
11/28	2029	15 53.1833	63 37.1587	HRP	141	1500	HRP recovered
11/29	0006	16 32.0452	63 37.0521	CTD	146	1000	
11/29	0006	16 32.0452	63 37.0521	HRP	142	1241	HRP deployed
11/29	0105	16 32.3718	63 37.0588	HRP	142	1241	HRP recovered
11/29	0455	16 50.0335	64 17.8287	CTD	147	1000	
11/29	0455	16 50.0335	64 17.8287	HRP	143	1448	HRP deployed
11/29	0610	16 50.3336	64 18.0196	HRP	143	1448	HRP recovered
11/29	1049	16 32.0401	64 58.0487	CTD	148	1000	
11/29	1049	16 32.0401	64 58.0487	HRP	144	1500	HRP deployed
11/29	1115	16 31.9225	64 58.2641	HRP	144	1500	HRP recovered
11/29	1437	15 52.9239	64 57.9618	CTD	149	1000	
11/29	1437	15 52.9239	64 57.9618	HRP	145	1500	HRP deployed
11/29	1600	15 52.7490	64 57.8935	HRP	145	1500	HRP recovered
11/29	1935	15 14.0253	64 58.0117	CTD	150	1000	
11/29	1935	15 14.0253	64 58.0117	HRP	146	1500	HRP deployed
11/29	2040	15 14.1119	64 58.0184	HRP	146	1500	HRP recovered
11/30	0021	14 34.9248	65 08.0564	CTD	151	1000	
11/30	0021	14 34.9248	65 08.0564	HRP	147	1500	HRP deployed
11/30	0127	14 34.9077	65 08.1524	HRP	147	1500	HRP recovered
11/30	0455	13 55.84	65 18.14	CTD	152	1000	
11/30	0502	13 55.7424	65 18.2044	HRP	148	1500	HRP deployed
11/30	0609	13 55.5630	65 18.2197	HRP	148	1500	HRP recovered
11/30	0928	13 16.9981	65 28.1215	CTD	153	1000	
11/30	0928	13 16.9981	65 28.1215	HRP	149	1500	HRP deployed
11/30	1050	13 16.7142	65 28.5867	HRP	149	1500	HRP recovered
11/30	1417	12 38.0071	65 38.0264	CTD	154	1000	
11/30	1417	12 38.0071	65 38.0264	HRP	150	1500	HRP deployed
11/30	1521	12 38.0000	65 38.0377	HRP	150	1500	HRP recovered
11/30	1853	12 38.0392	66 18.0544	CTD	155	1000	
11/30	1852	12 38.0392	66 18.0544	HRP	151	1500	HRP deployed
11/30	1957	12 38.1174	66 18.2650	HRP	151	1500	HRP recovered
11/30	2330	13 16.0277	66 29.9873	CTD	156	1000	
11/30	2330	13 16.0277	66 29.9873	HRP	152	1500	HRP deployed

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12/01	0037	13 16.0221	66 30.0484	HRP	152	1500	HRP recovered
12/01	0411	13 54.0187	66 42.0559	CTD	157	1000	
12/01	0411	13 54.0187	66 42.0559	HRP	153	1500	HRP deployed
12/01	0516	13 54.5744	66 42.0504	HRP	153	1500	HRP recovered
12/01	0850	14 31.9941	66 54.0115	CTD	158	1000	
12/01	0850	14 31.9941	66 54.0115	HRP	154	1500	HRP deployed
12/01	0955	14 32.0162	66 53.9892	HRP	154	1500	HRP recovered
12/01	1232	14 46.0229	67 32.0434	CTD	159	1000	
12/01	1232	14 46.0229	67 32.0434	HRP	155	1500	HRP deployed
12/01	1435	14 46.1269	67 32.0262	HRP	155	1500	HRP recovered
12/01	1809	15 0.0000	68 10.0426	CTD	160	1000	
12/01	1809	15 0.0000	68 10.0426	HRP	156	1500	HRP deployed
12/01	1912	14 59.6843	68 90.9932	HRP	156	1500	HRP recovered
12/01	2252	15 14.0277	68 48.0118	CTD	161	1000	
12/01	2252	15 14.0277	68 48.0118	HRP	157	1500	HRP deployed
12/02	1912	15 13.6843	68 47.8726	HRP	157	1500	HRP recovered
12/02	0350	15 27.9885	69 25.9260	CTD	162	1000	
12/02	0350	15 27.9885	69 25.9260	HRP	158	1500	HRP deployed
12/02	0456	15 27.8444	69 25.5078	HRP	158	1500	HRP recovered
12/02	0840	15 42.0149	70 01.9791	CTD	163	1000	
12/02	0840	15 42.0149	70 01.9791	HRP	159	1500	HRP deployed
12/02	0943	15 41.9999	70 01.5788	HRP	159	1500	HRP recovered
12/02	1322	16 09.0301	70 31.0266	CTD	164	1000	
12/02	1322	16 09.0301	70 31.0266	HRP	160	1500	HRP deployed
12/02	1427	16 08.8113	70 30.7798	HRP	160	1500	HRP recovered
12/02	1819	16 39.2180	69 59.6737	CTD	165	1000	
12/02	1819	16 39.2180	69 59.6737	HRP	161	1500	HRP deployed
12/02	1924	16 39.2182	69 59.8098	HRP	161	1500	HRP recovered
12/02	2312	16 43.9831	69 17.9913	CTD	166	1000	
12/02	2312	16 43.9831	69 17.9913	HRP	162	1500	HRP deployed
12/03	0014	16 44.0383	69 18.1673	HRP	162	1500	HRP recovered
12/03	0402	16 44.0330	68 37.0599	CTD	167	1000	
12/03	0402	16 44.0330	68 37.0599	HRP	163	1500	HRP deployed
12/03	0508	16 44.0693	68 37.2811	HRP	163	1500	HRP recovered
12/03	0857	16 44.0455	67 56.9986	CTD	168	1000	
12/03	0857	16 44.0455	67 56.9986	HRP	164	1500	HRP deployed
12/03	1001	16 43.9510	67 56.0118	HRP	164	1500	HRP recovered
12/03	1346	16 43.9969	67 14.9857	CTD	169	1000	
12/03	1346	16 43.9969	67 14.9857	HRP	165	1399	HRP deployed
12/03	1452	16 43.9610	67 14.9333	HRP	165	1399	HRP recovered
12/05	1200	- -	- -	-	-	-	arr. Puerto Rico

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16. Abstract (Limit: 200 words)

The Salt Finger Tracer Release Experiment (SFTRE) was conducted in the tropical North Atlantic in 2001. The goal of this experiment was to quantify the vertical mixing in a thermohaline staircase subject to strong salt fingering. The experimental area selected is east of Barbados with prominent staircase layers prevalent in the depth range of 200 - 600 meters. Two cruises were required to complete this experiment: one in January to select an injection site, inject sulfur hexafluoride (SF6) tracer, and survey with the High Resolution Profiler (HRP), followed by another ten months later to map the spatial distribution of tracer and obtain estimates of diffusive and turbulent mixing rates using the HRP. The deployment of a Moored Profiler (MP) at 13N 55W was another component of the SFTRE. The temperature salinity and velocity profiles collected by the MP were expected to span the time between the two cruises, providing background on the temporal variation of staircases. The mixing observed in the SFTRE was stronger and the influence of the processes associated with the thermohaline staircases more widespread than expected.

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thermohaline staircase
diffusive mixing

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

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